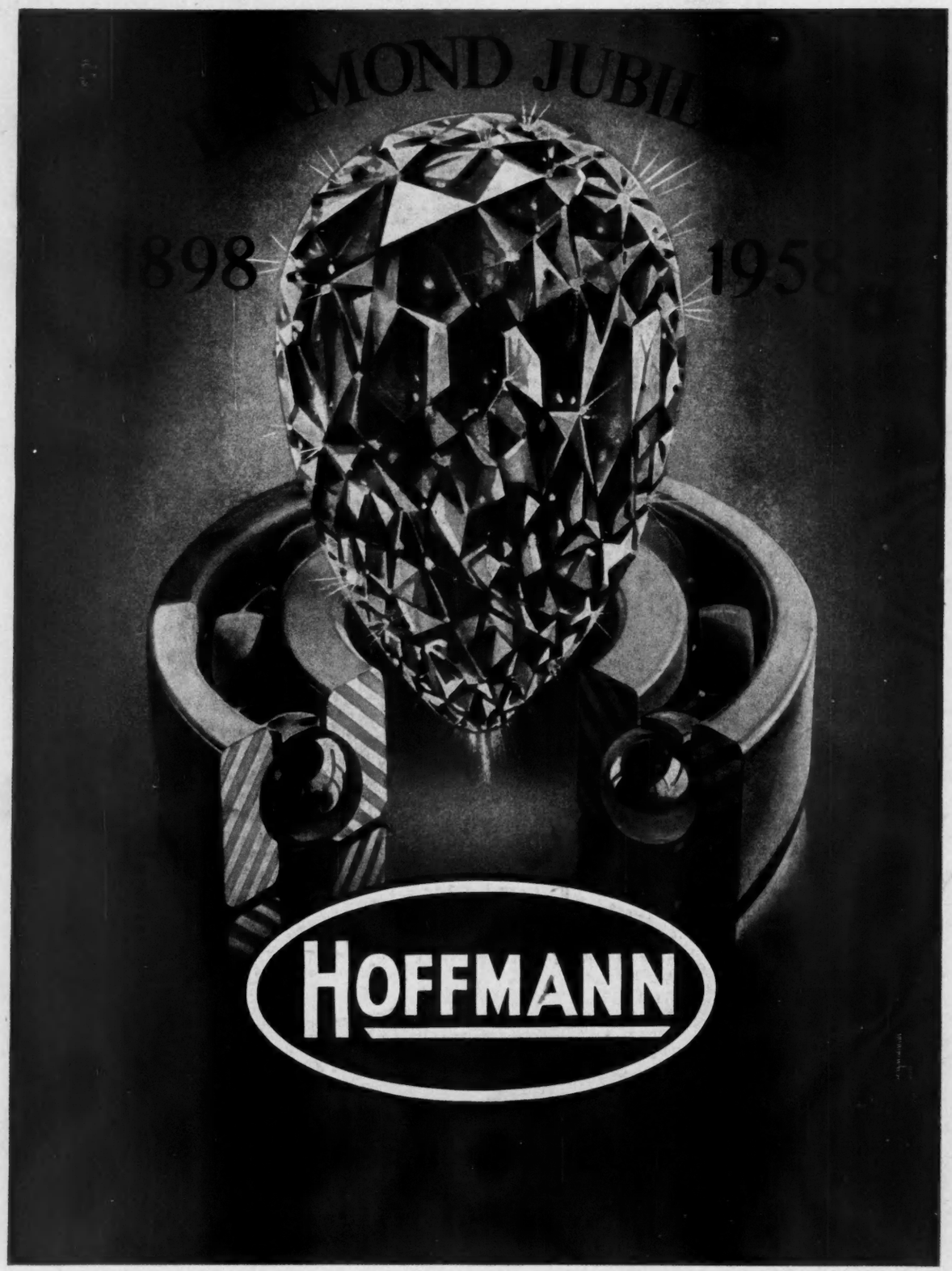
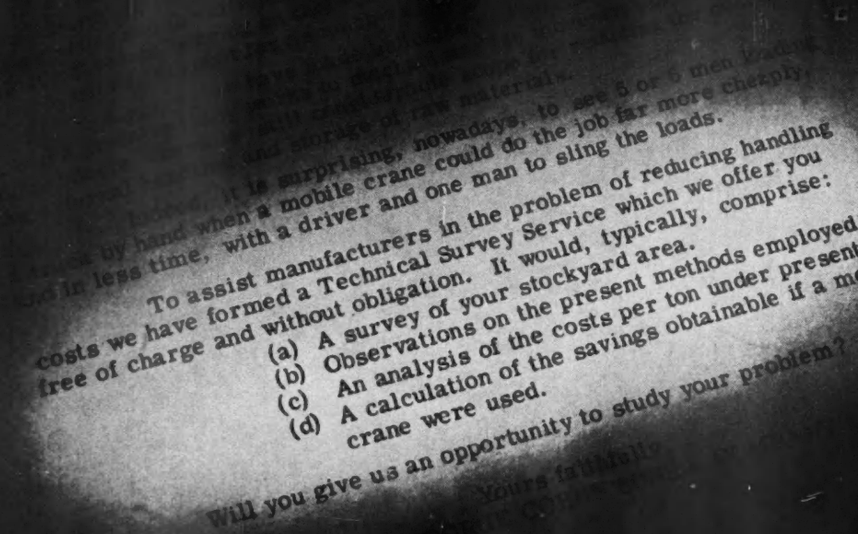
# The Engineer

JULY 4, 1958 28 ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS



# FOR ACTION please!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costs we have formed a Technical Survey Service which we offer you
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(b) Observations on the present methods employed.
(c) An analysis of the costs per ton under present methods
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*Established* 1856

No. 5345 **JULY 4, 1958** VOL. 206

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SUBSCRIPTIONS U.K. and ABROAD £5 10. 0. p.a., including postage (CANADA £5 5. 0.). Single copies 2s. each, plus 9d. postage. Also on sale at newsagents.

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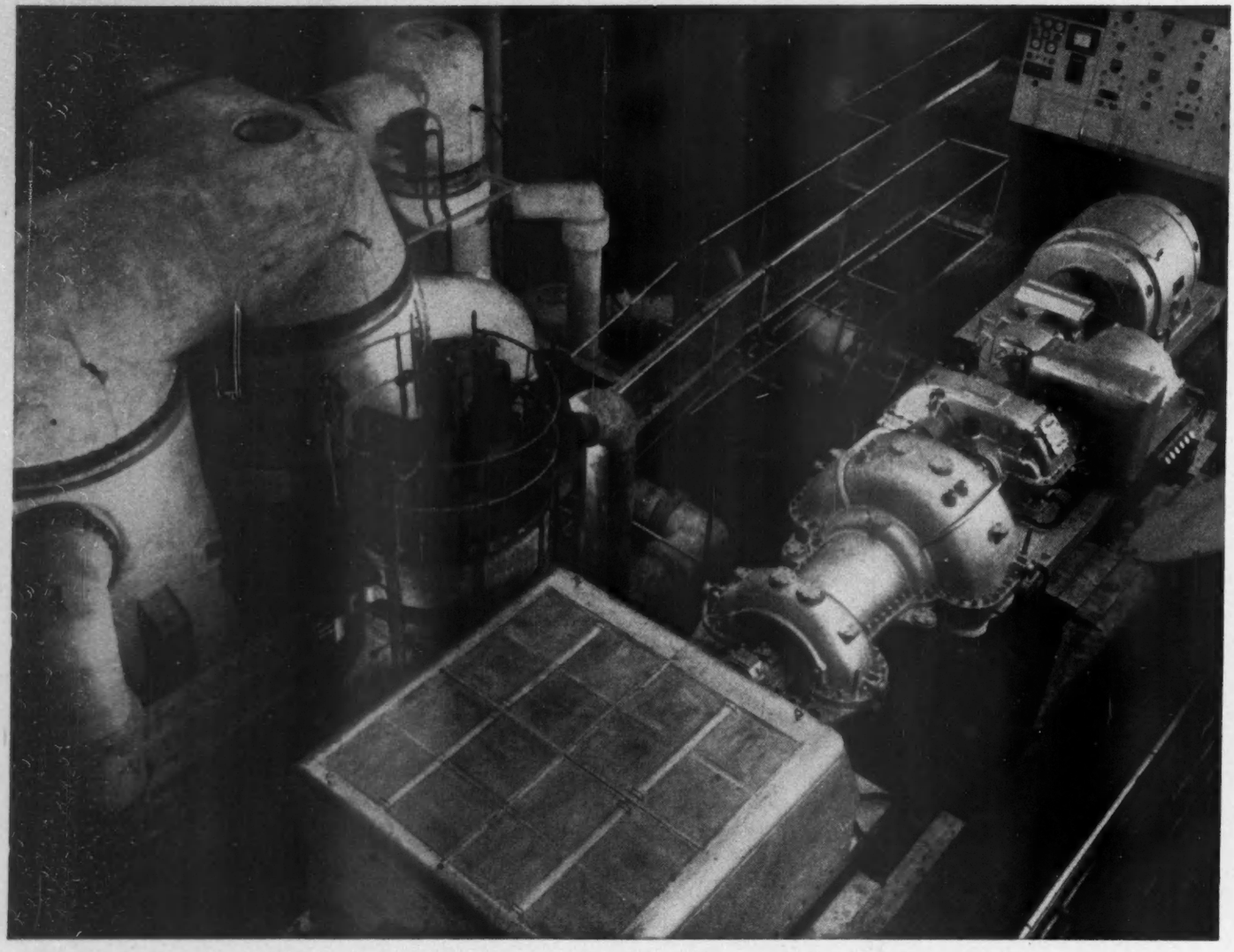

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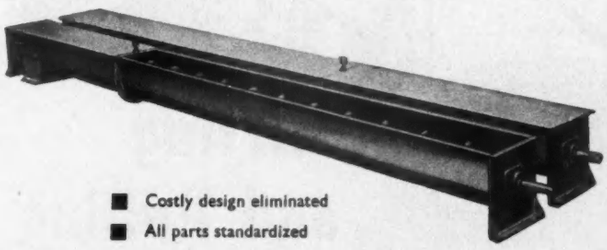

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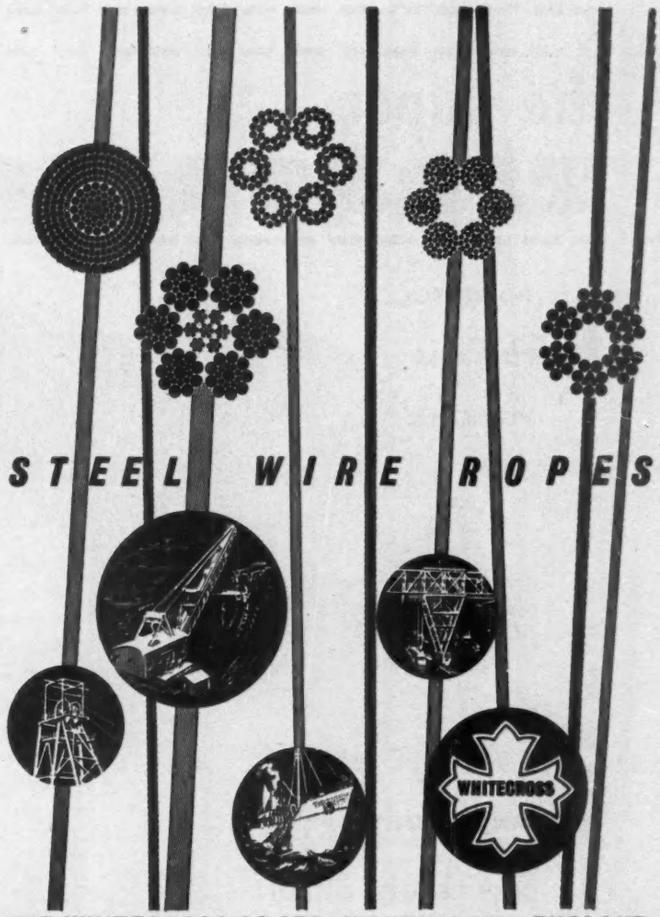


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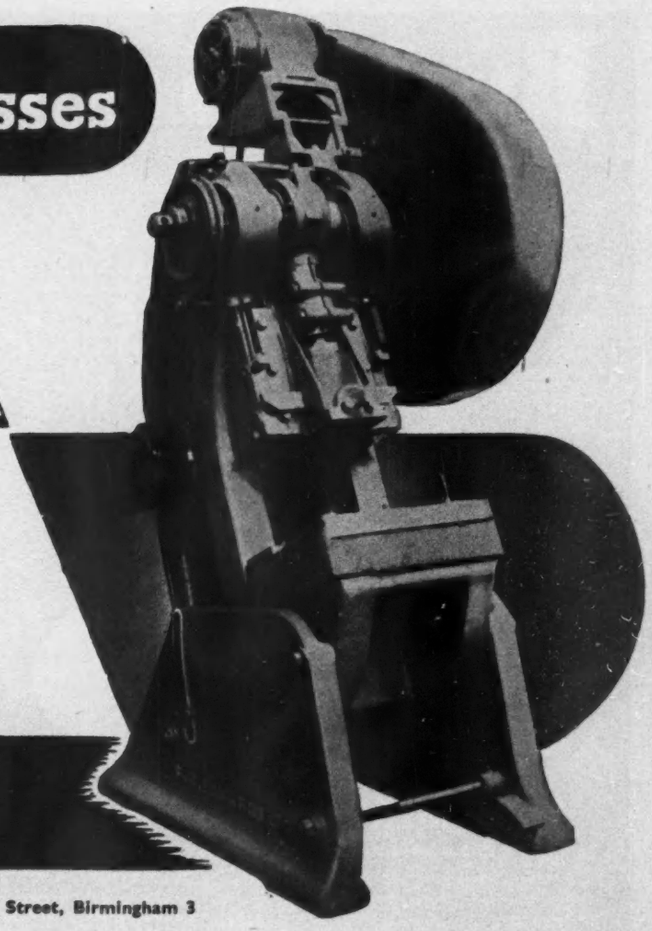

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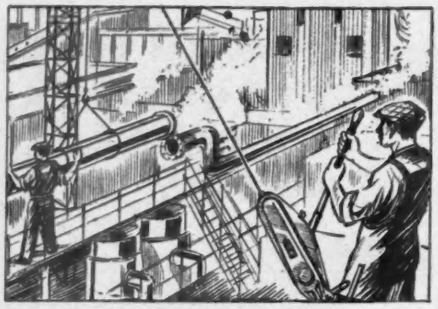

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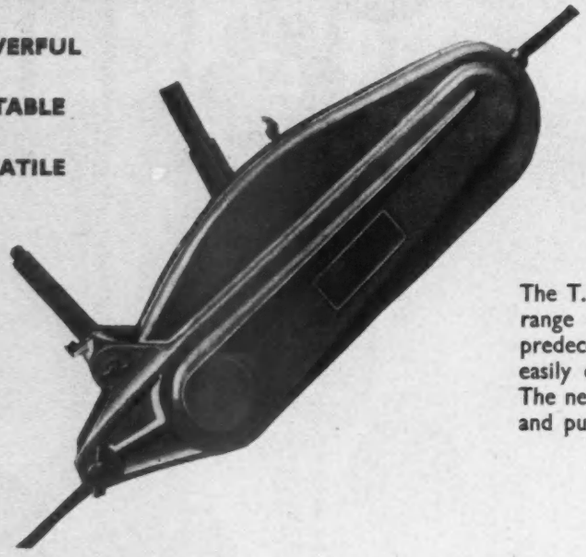

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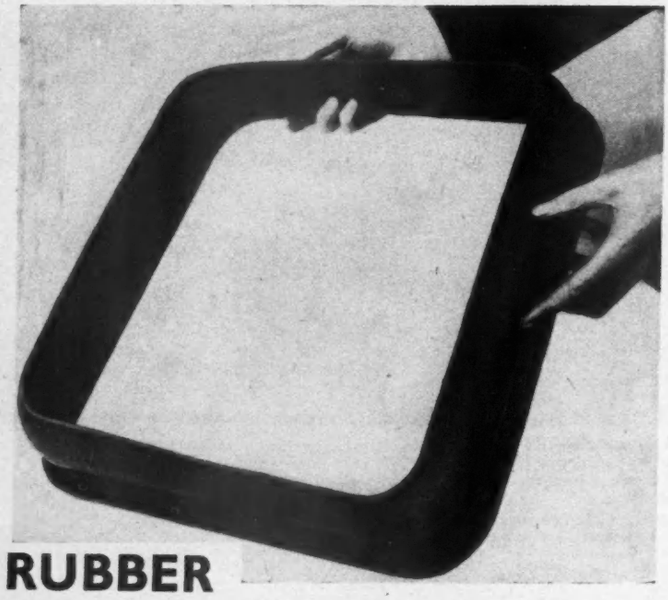

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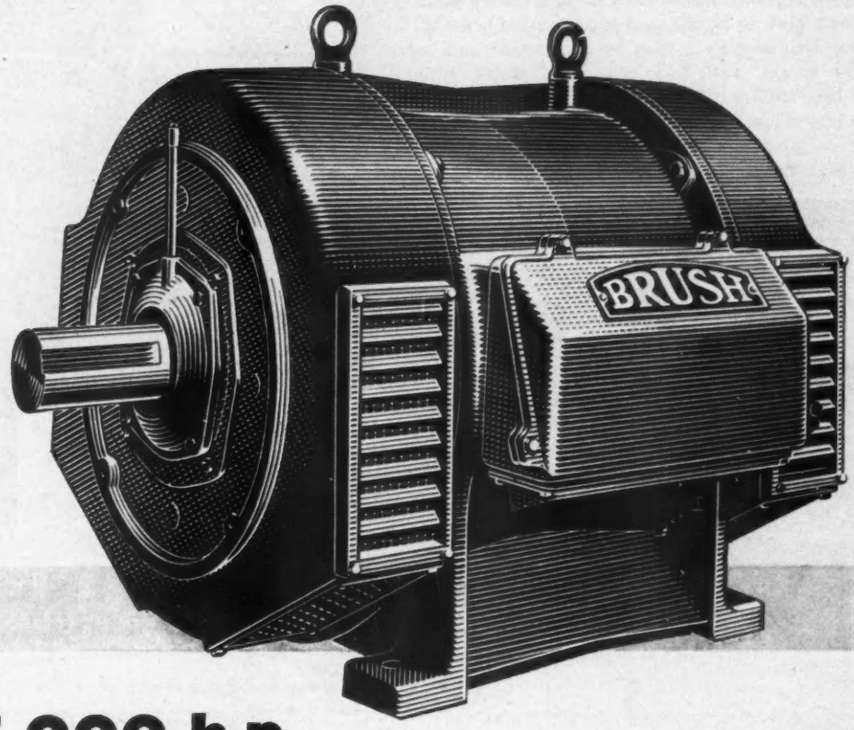


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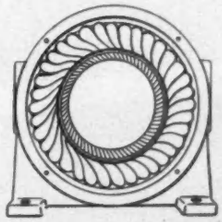

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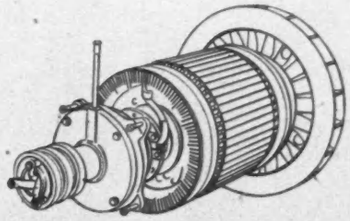

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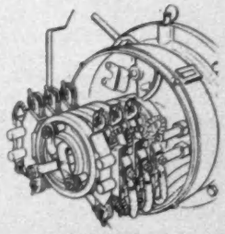

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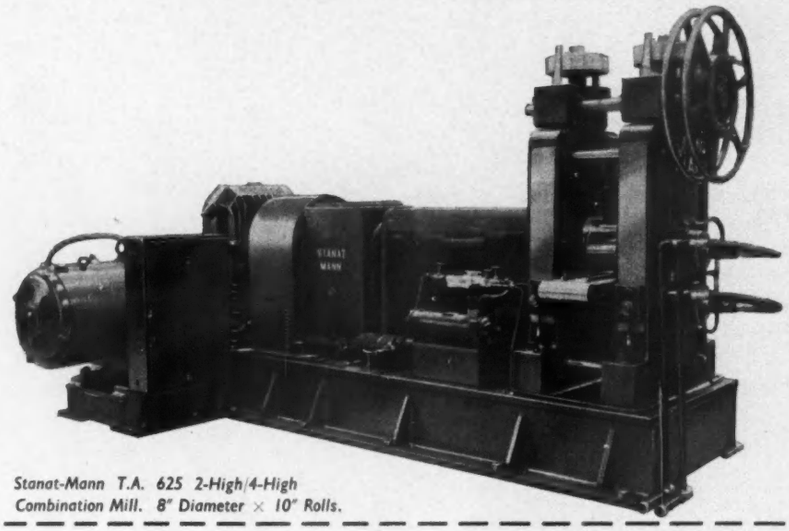

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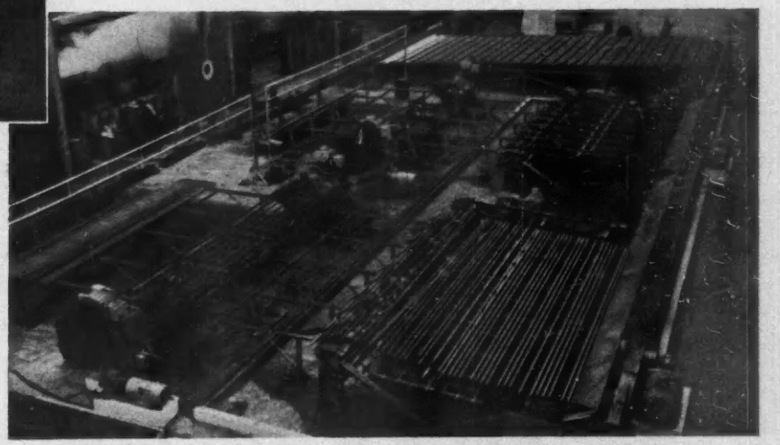
LEFT. Roll Race Bus Conveyor typical of application of the most efficient heavy load conveyor in the world.

BELOW. Installation for conveying and handling hot steel tubes shown is typical contract installation undertaken.



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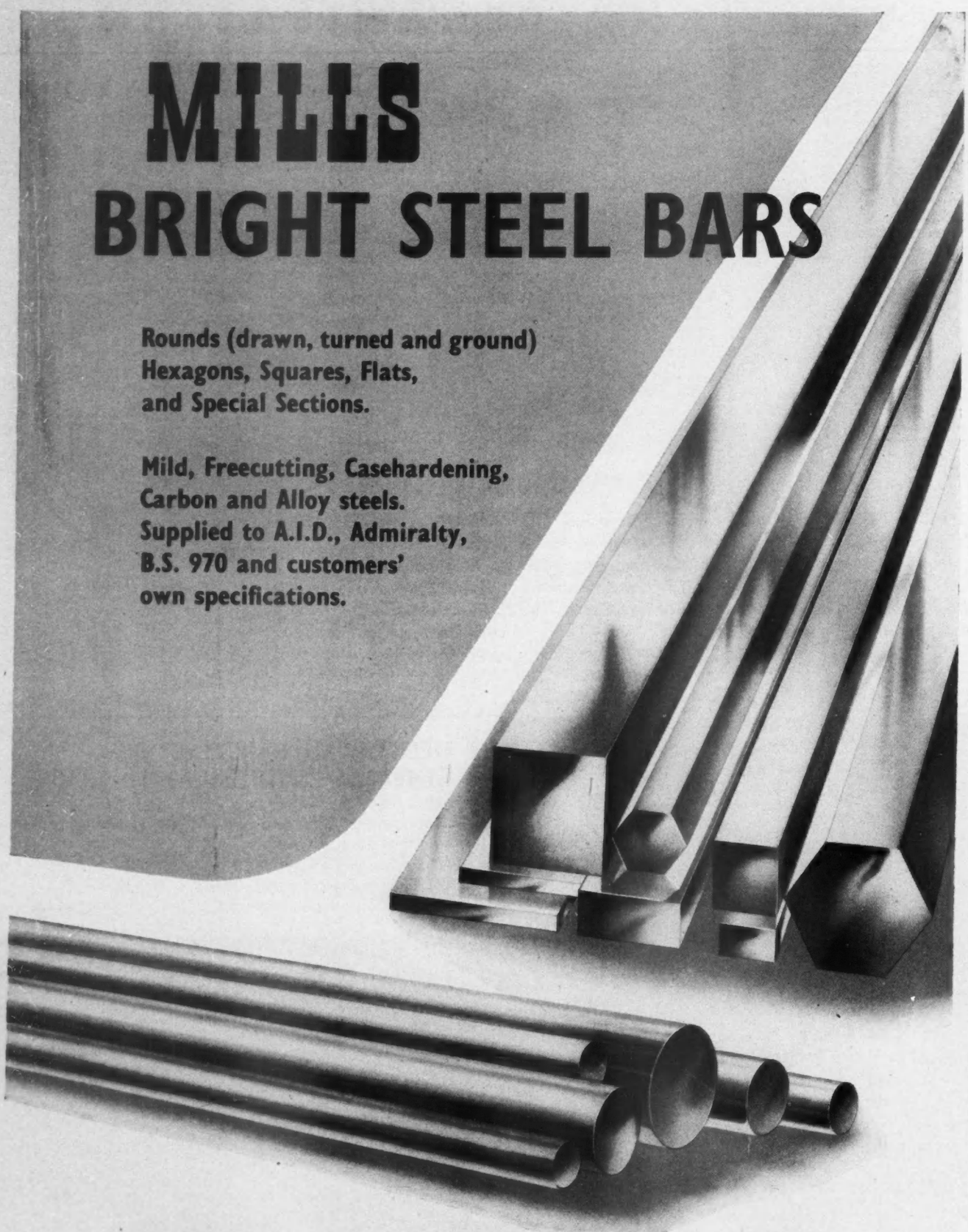

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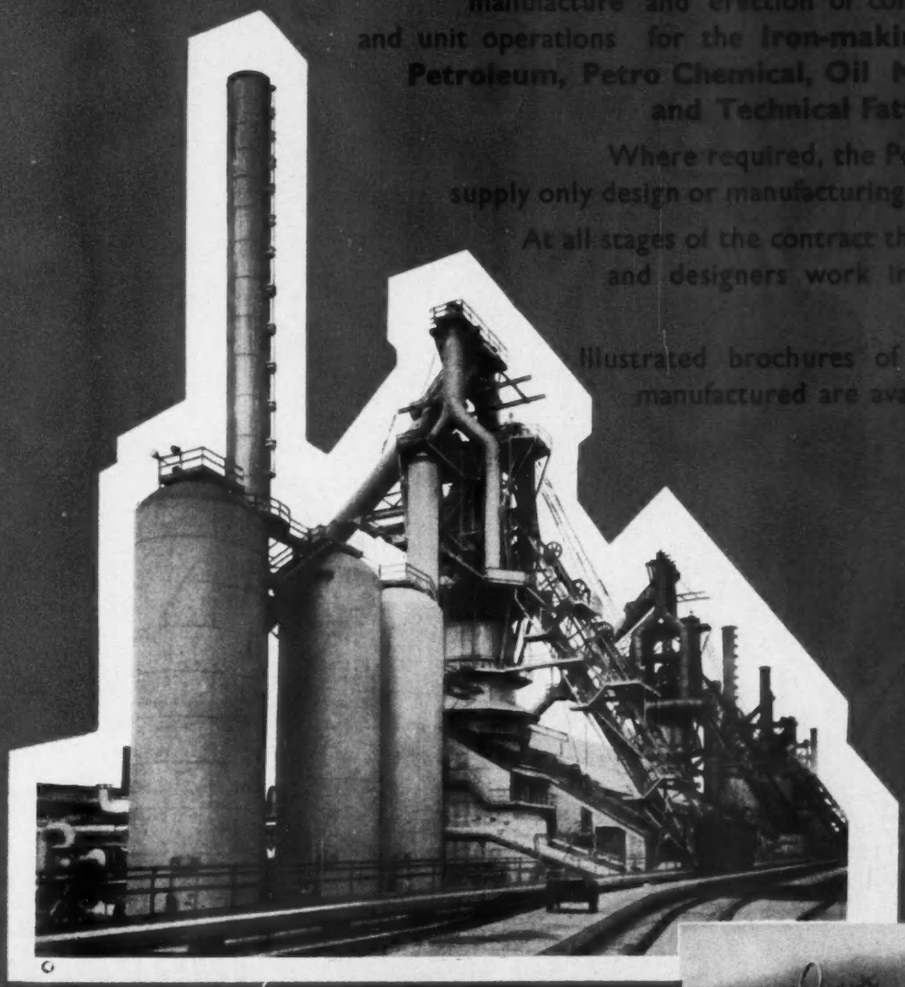

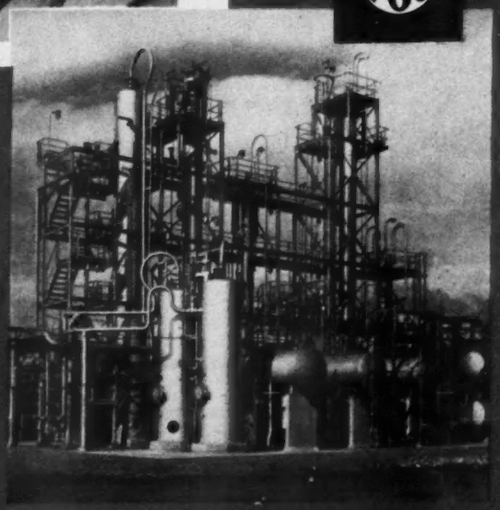

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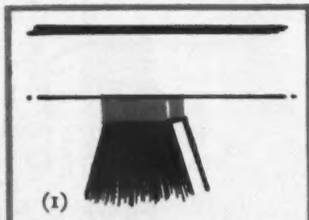
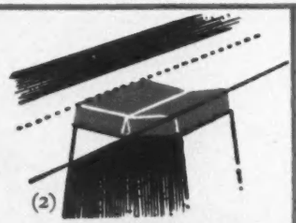
The promoters of this bridge are the Lincoln City Council, the Consulting Engineers, W. S. Atkins & Partners in association with A. Aldington, A.M.I.C.E., M.I.Mu.E., City Engineer and Surveyor. The Consulting Architects are Robert Atkinson & Partners.

*The end of the Pelham Bridge where it joins the approach. The rubber bridge mountings can be seen at the top of each of the eight columns.*



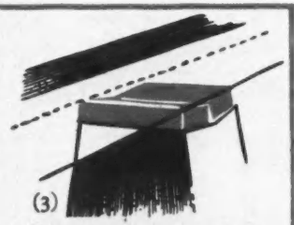
(1)

One mounting placed flat replaces two sets of roller bearings, one on top of the other, and a rocker bearing.



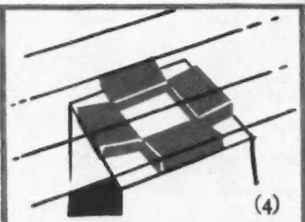
(2)

Two mountings placed as a V in the line of the bridge span replace one rocker and one roller bearing and provide lateral stiffness.



(3)

Two mountings placed as a V across the line of the bridge span replace a straight rocker and provide longitudinal stiffness.

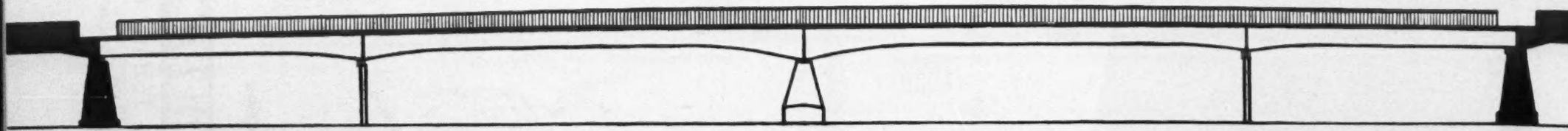


(4)

A combination of (2) and (3) in the form of a square replaces a spherical bearing.

**Advantages over conventional bearing:—**

- The maximum resistance to expansion is equivalent to a sliding bearing with a coefficient of friction of 0.07 (lubricated bronze on steel is 0.1).
- A flat-mounted bearing will accommodate movement in any direction.
- Needs no maintenance.
- The compression rating is such that the bearing can be regarded as a pinned support.



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An actual phase-to-earth fault is applied momentarily and the Tester checks that the prospective fault current of three times the fuse rating can flow.

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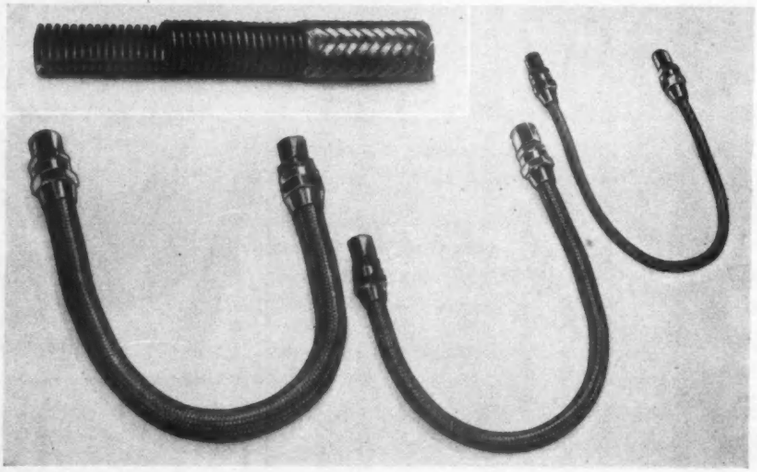

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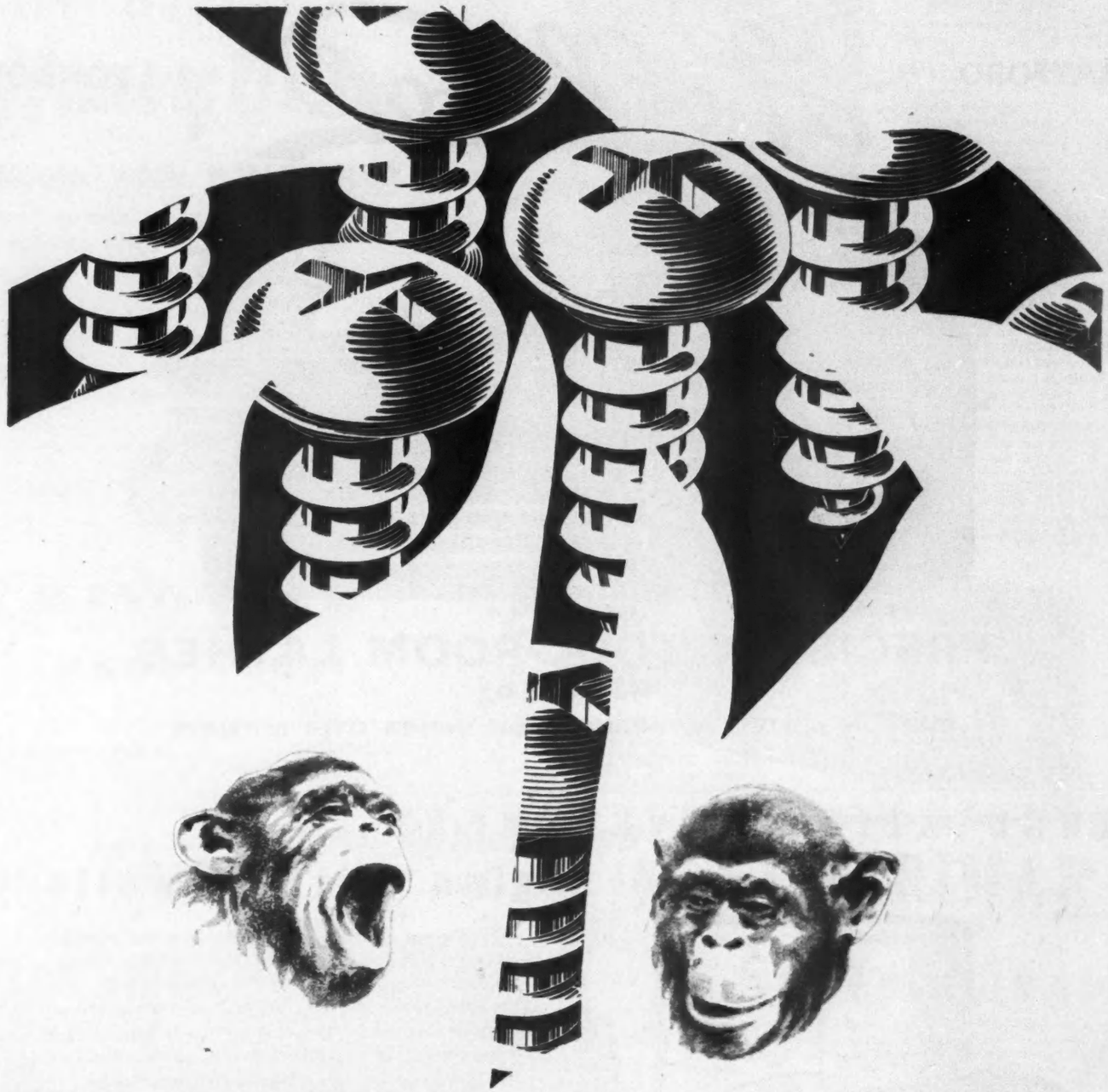

# what, no nuts? . . .

Nuts to use nuts? Well, not exactly, but the fact that the Tapping Screw obviates the use of nuts is just one of its distinct advantages over the conventional Machine Screw. There's the saving in time to consider too. And cost. And there's no doubt whatever that the tapping screw makes for a better job all round. With its self-locating point the tapping screw forms its own thread thereby eliminating a separate and expensive tapping operation. Obviously it makes for easier assembly, is stronger, cheaper and faster. Safer too when the Phillips recessed head is specified, designed for power driving without damage to worker or job. You'll be well advised to change over to Tapping Screws. Nothing nuts about that !

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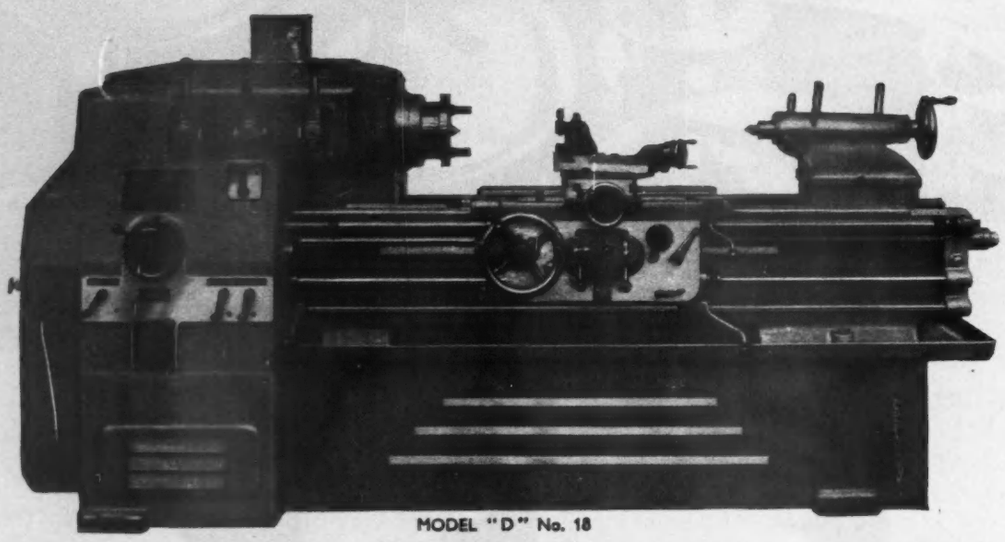

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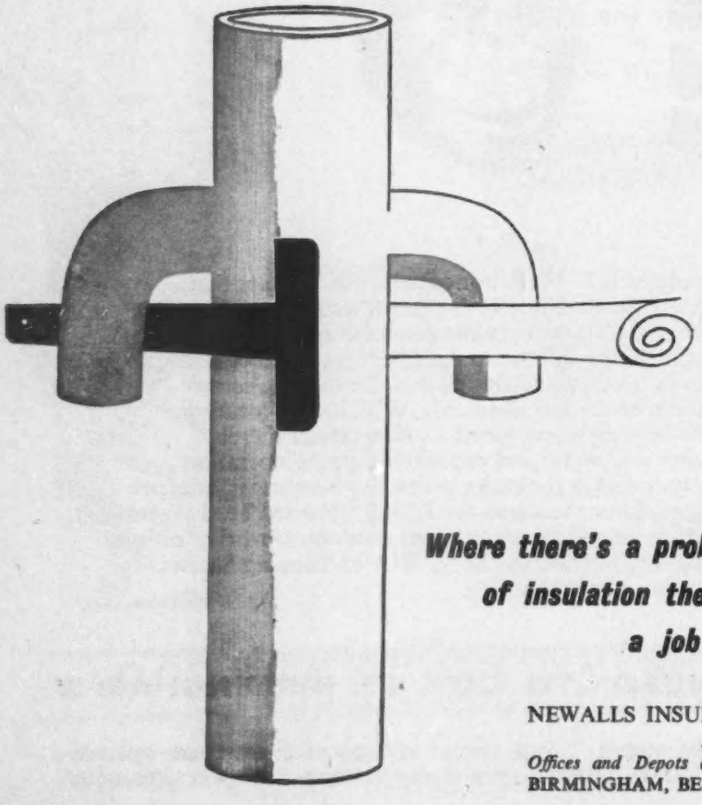

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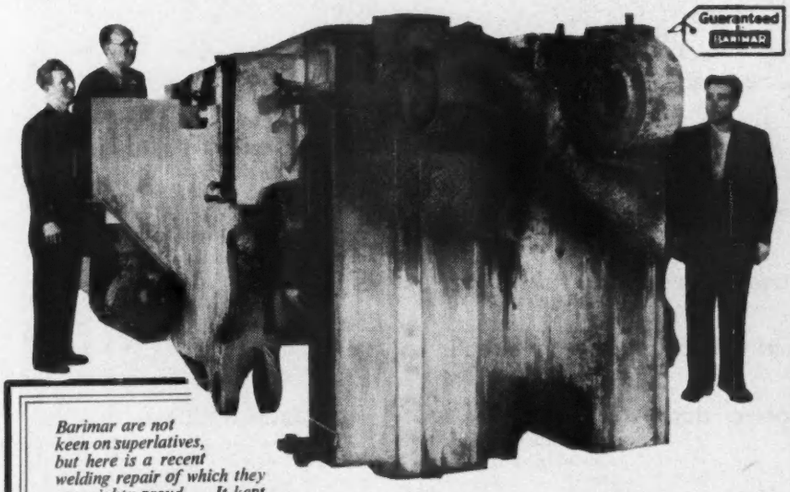


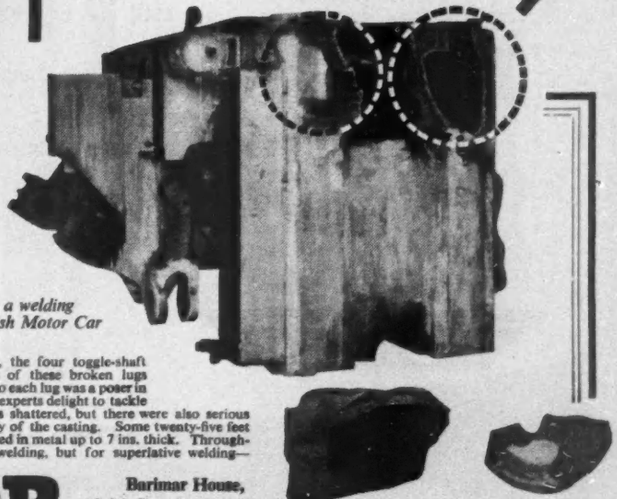



*Barimar are not keen on superlatives, but here is a recent welding repair of which they are mighty proud. It kept Barimar experts steadily on the job working in relays, day and night, for over a fortnight. It was a welding job in which every moment counted, for many thousands of pounds of productive work for the British Motor Car industry was at stake!*

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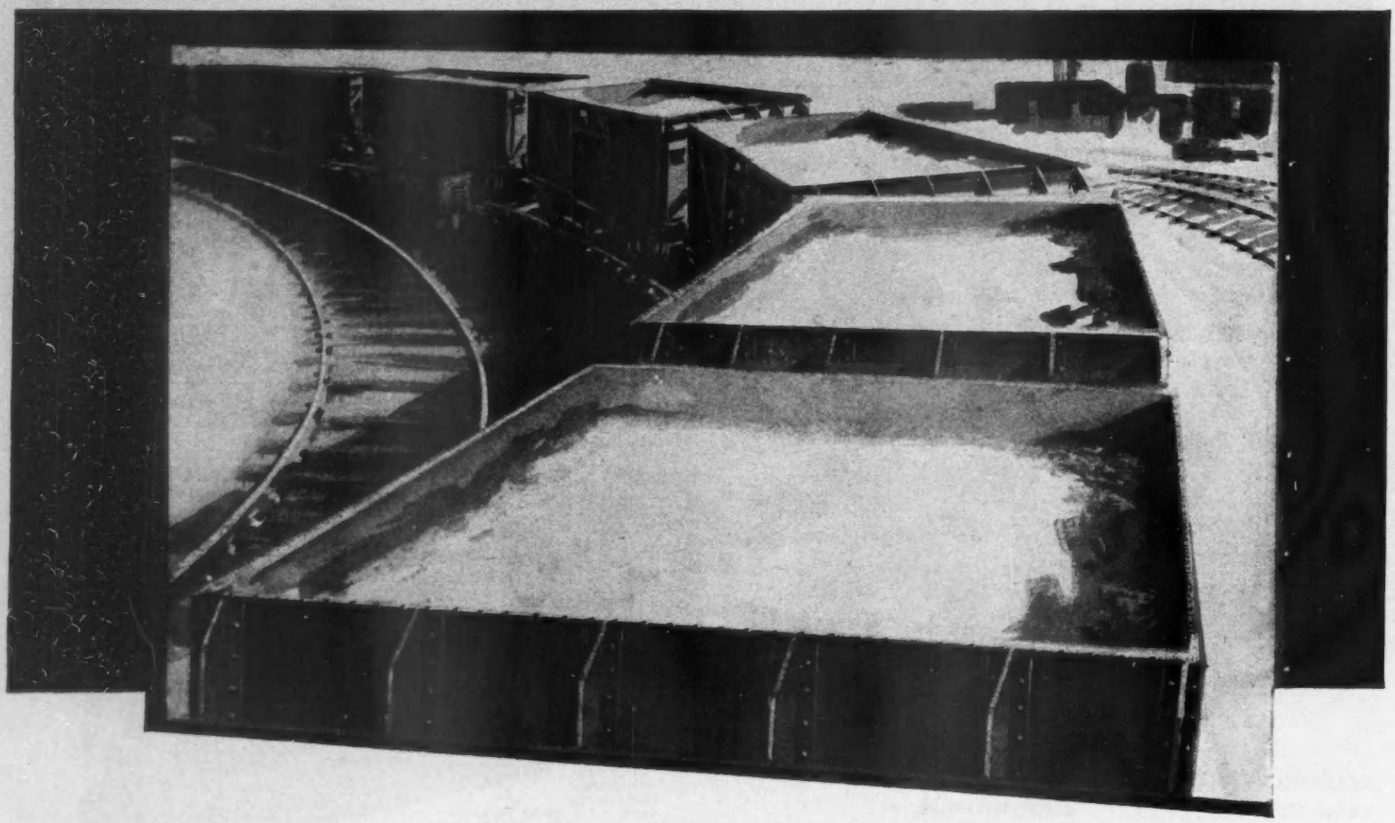

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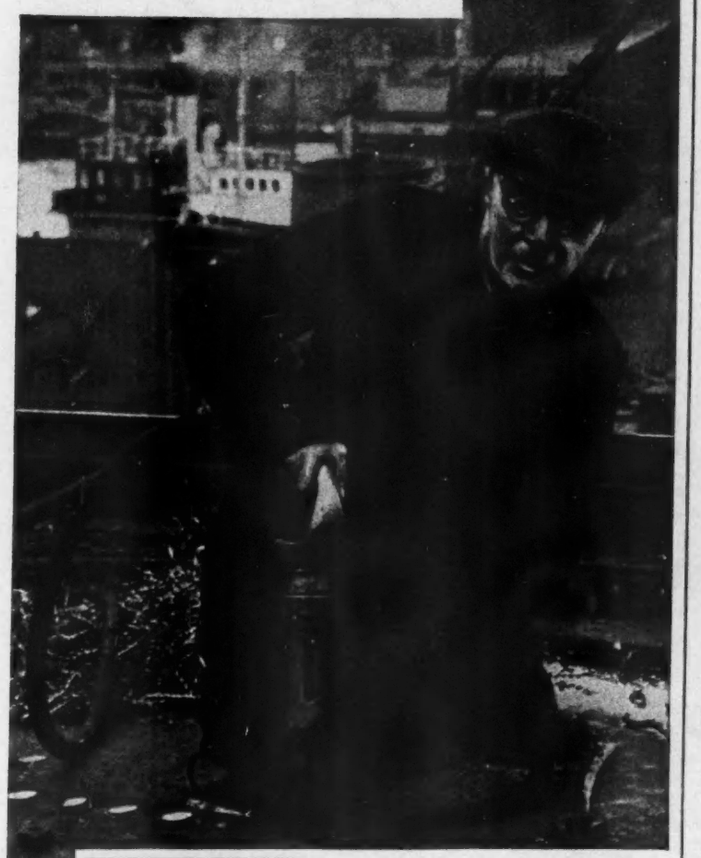

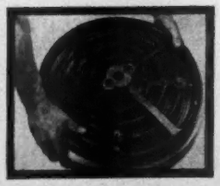

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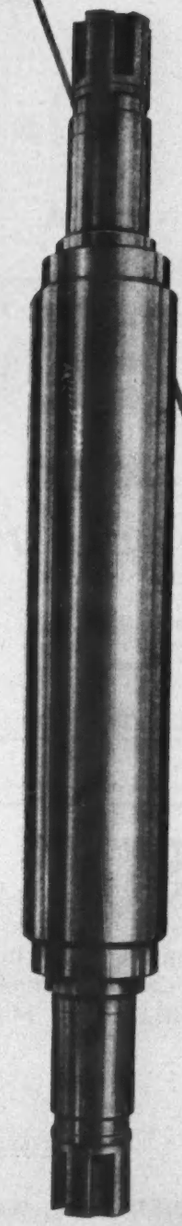

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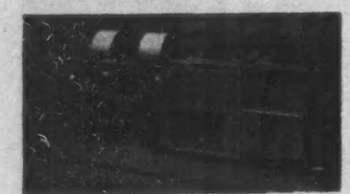

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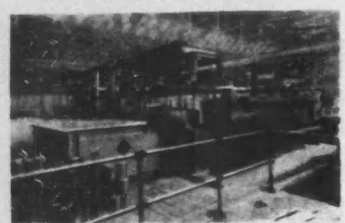

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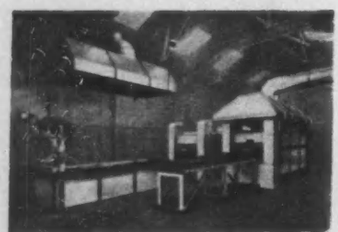

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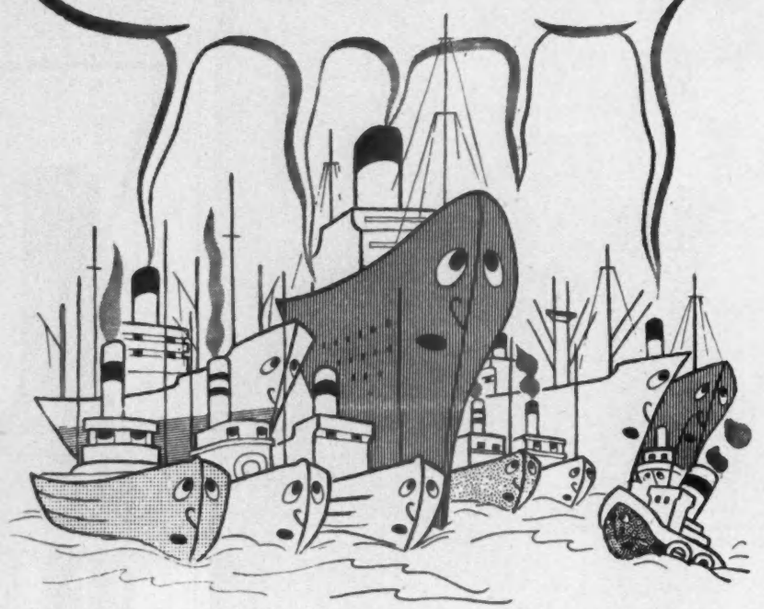

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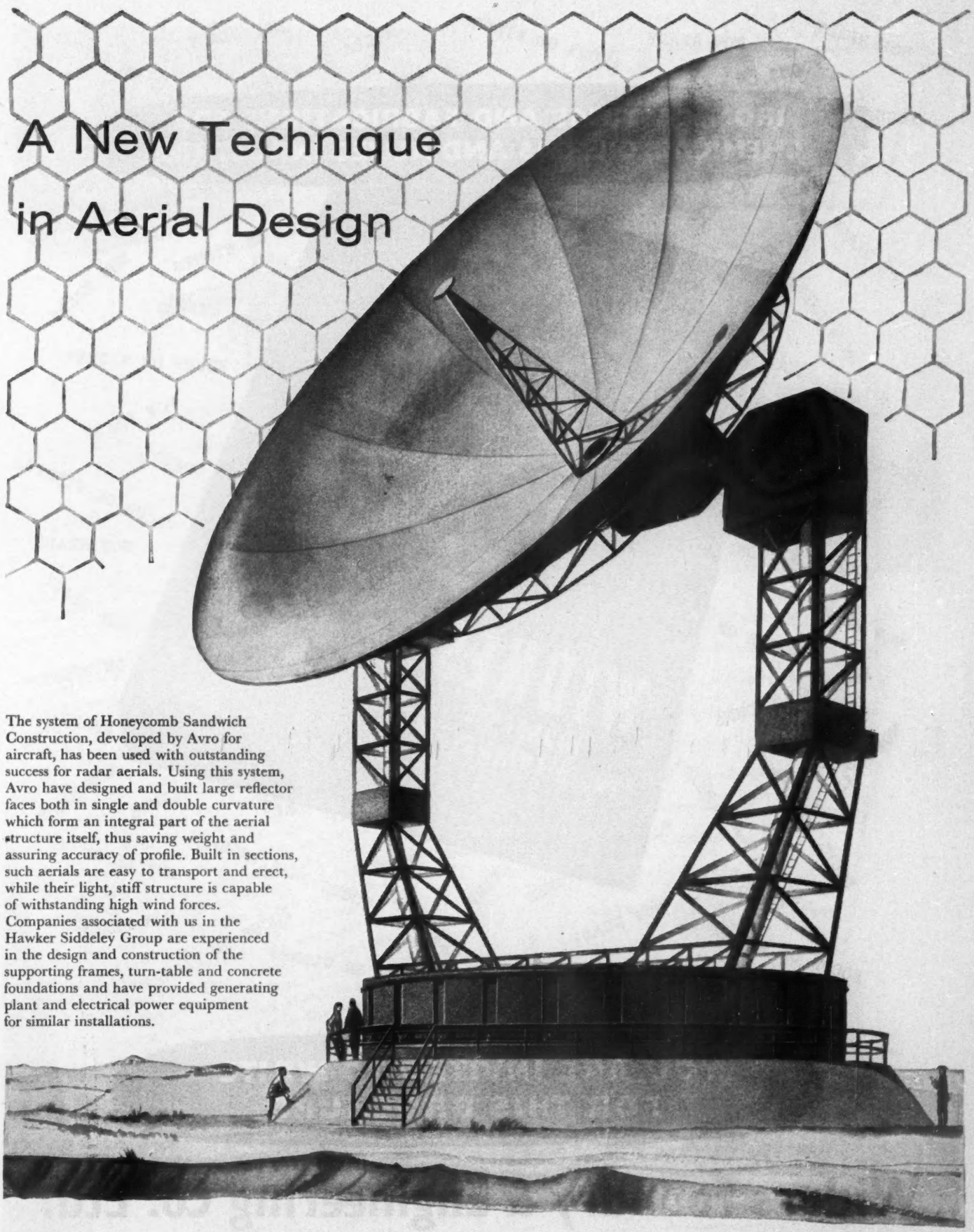

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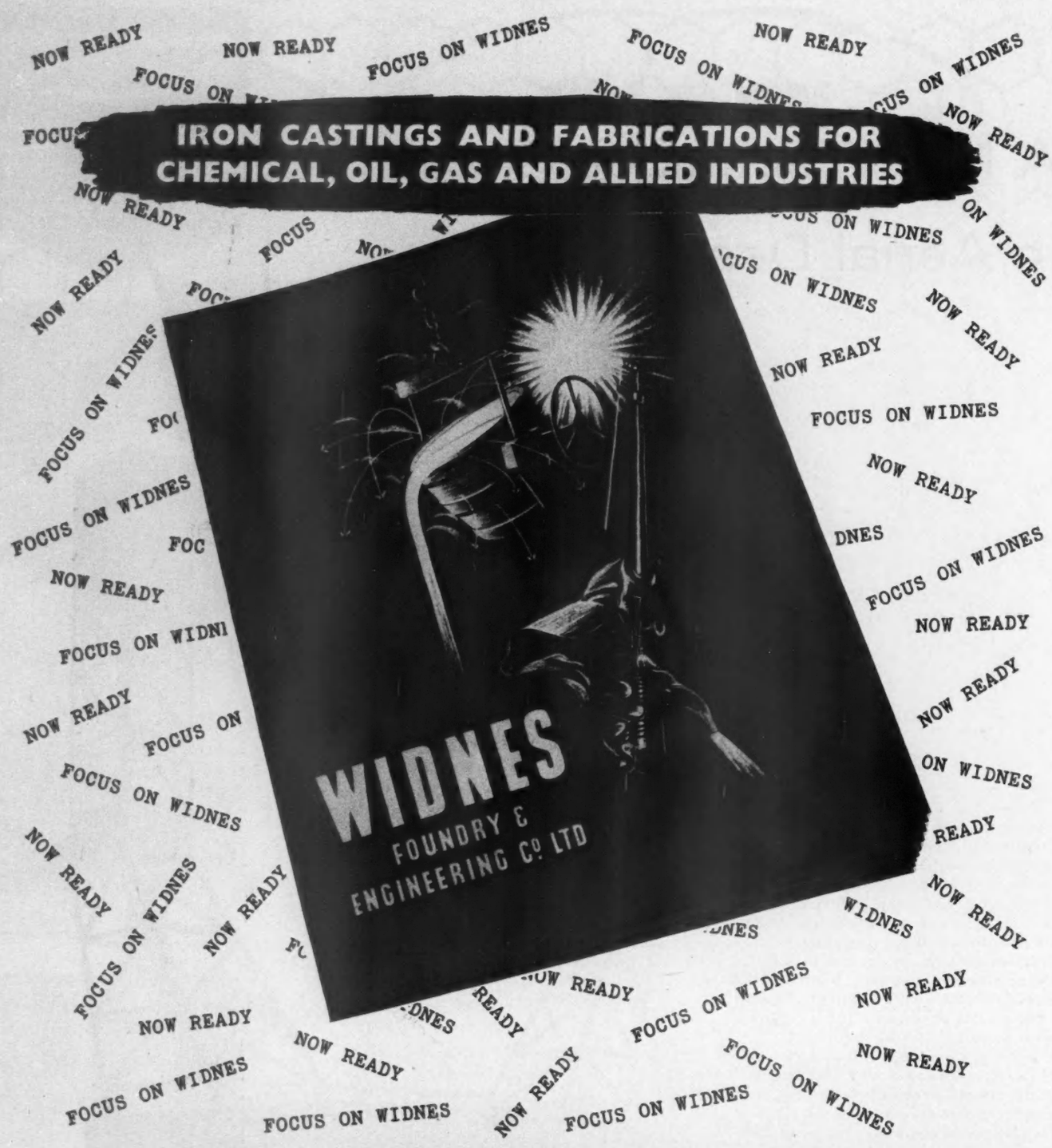


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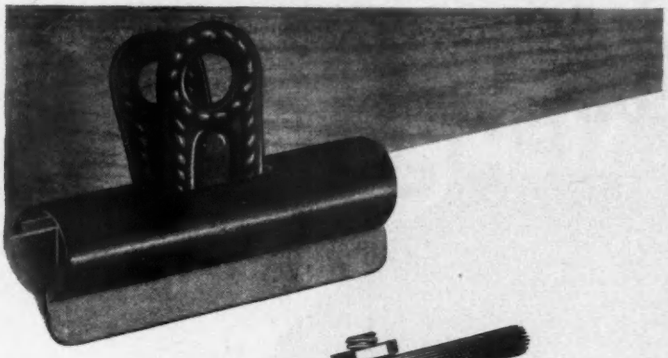

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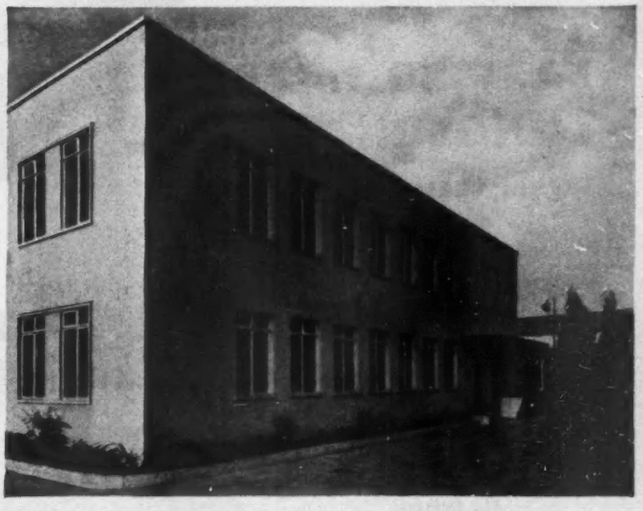

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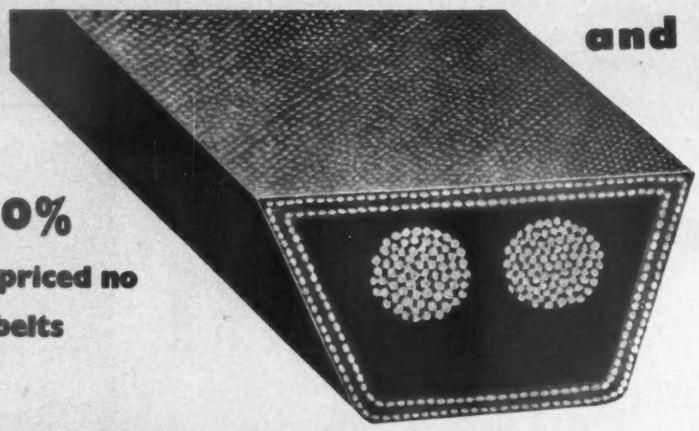

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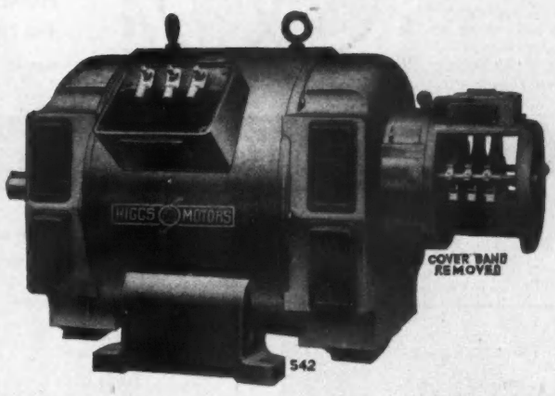


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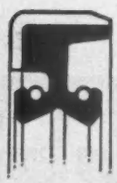
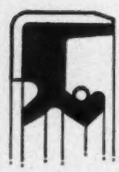


**TYPE 12 P**

A rotary shaft seal used to separate two different fluids.



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Similar to type 12P but without a spring on the second lip which serves as a dust excluder.

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## O-RINGS AND HYDRAULIC PACKINGS

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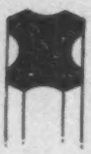
A springless seal used as a wiper or dust excluder for rotating or reciprocating shafts.

**TYPE 7 P**

A hydraulic and pneumatic seal used chiefly on reciprocating pistons or as a valve stem packing. Normally fitted in a groove.



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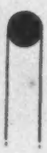
A special section ring which cannot twist. Superior to the O-ring for low and medium pressure non-static applications.



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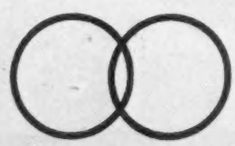

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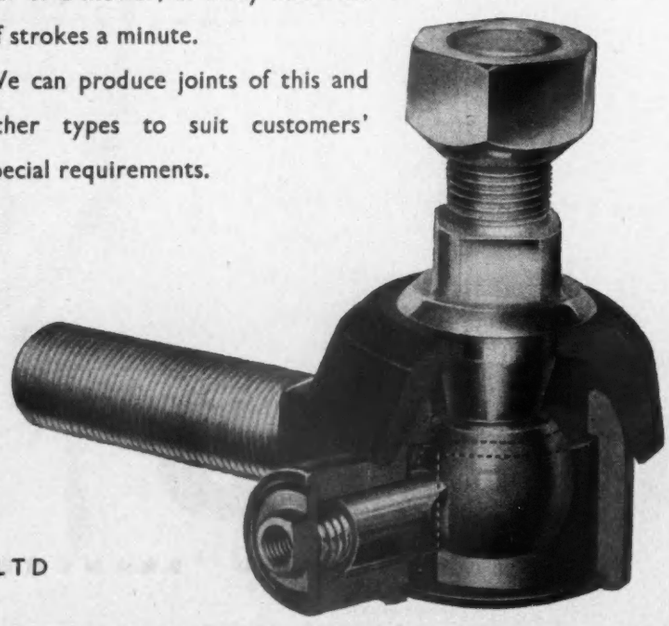

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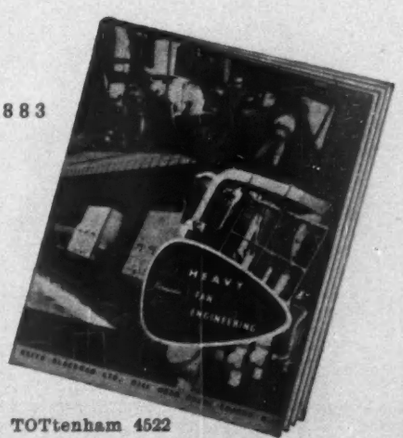


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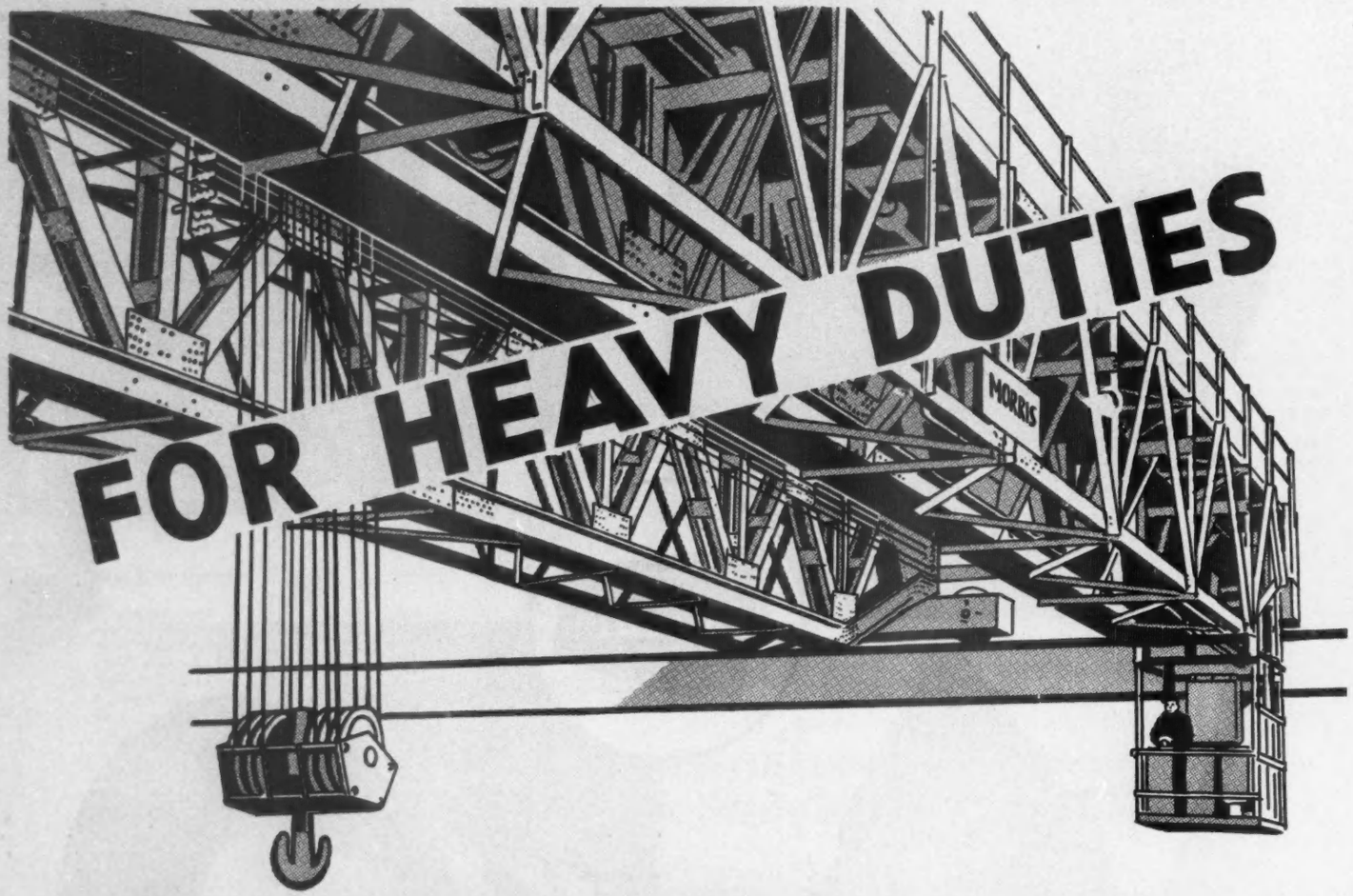

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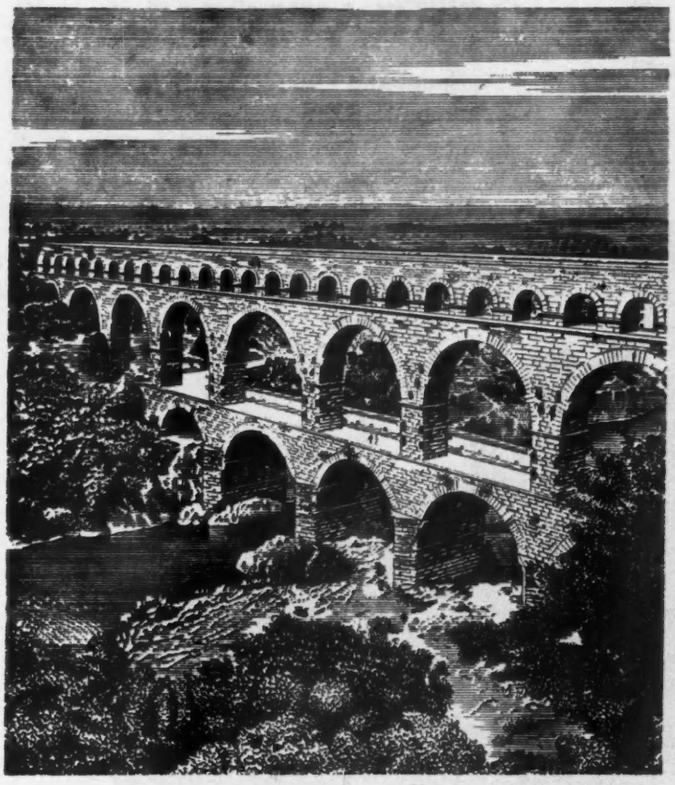

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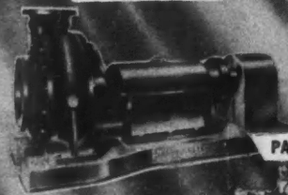

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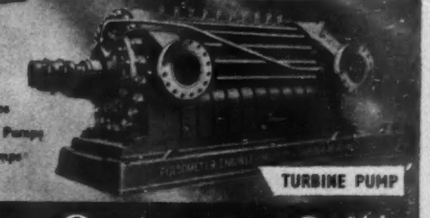

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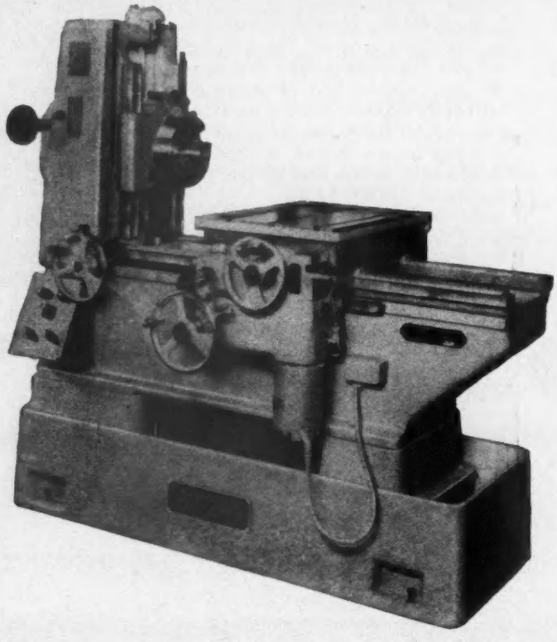

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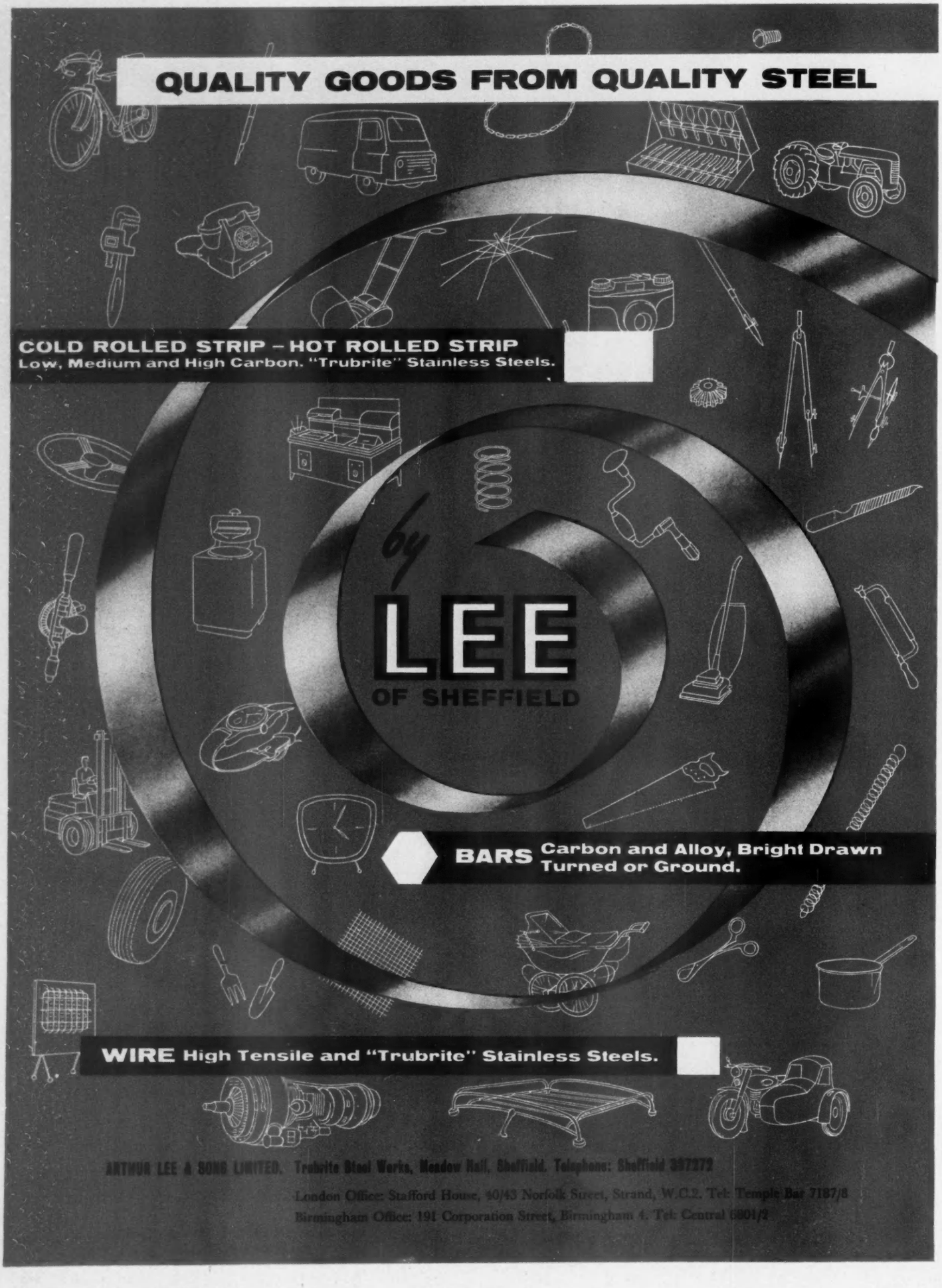
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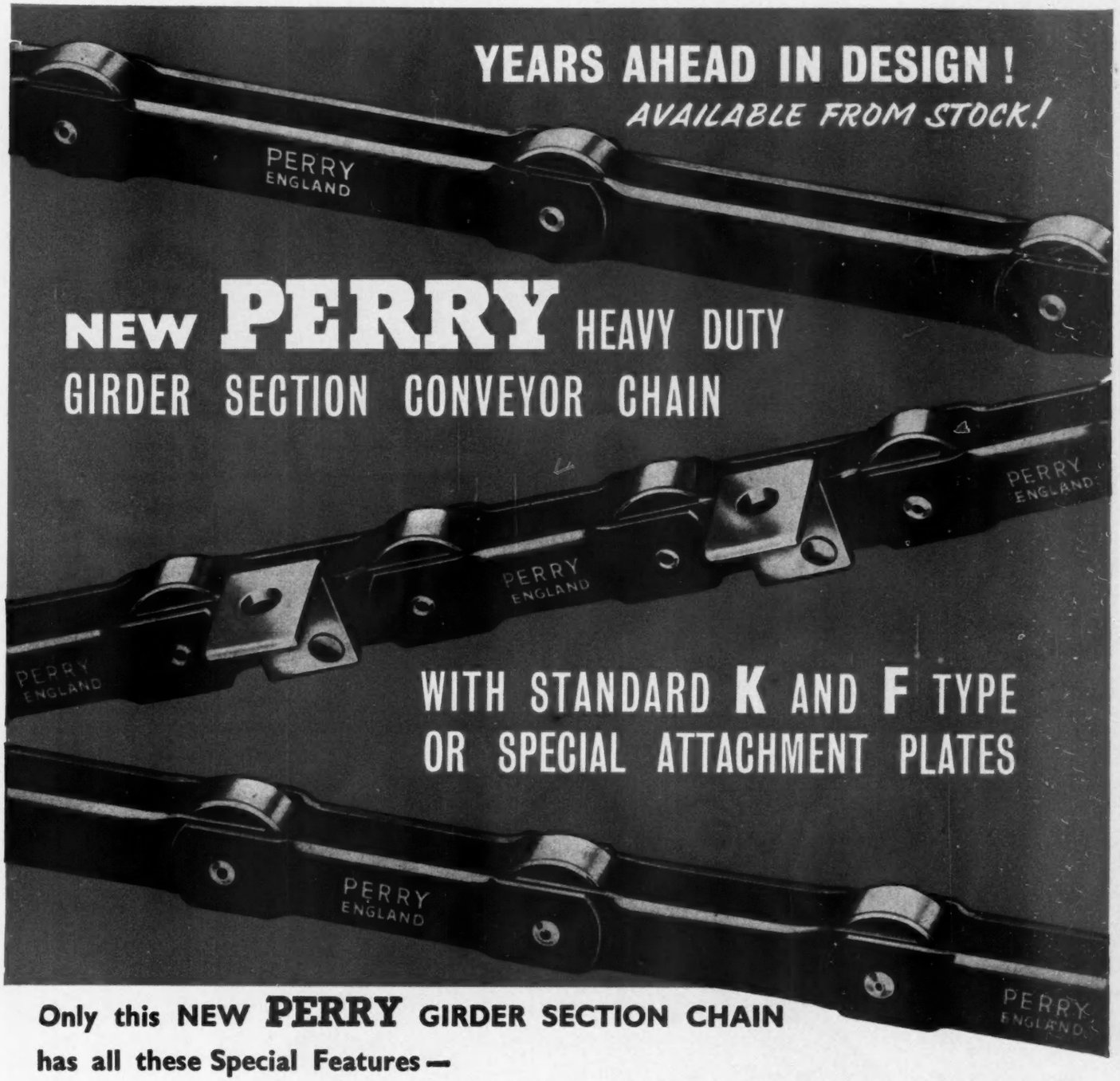


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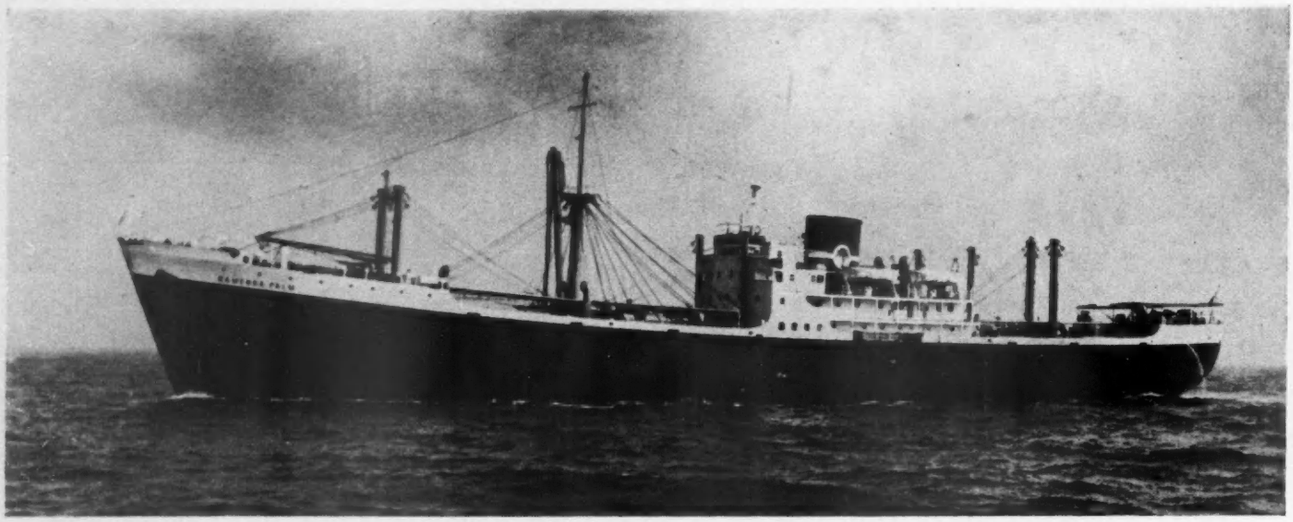

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AF 163

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### FOR LOADS UP TO 8 TONS
### PIPE MOVEMENTS UP TO 18″

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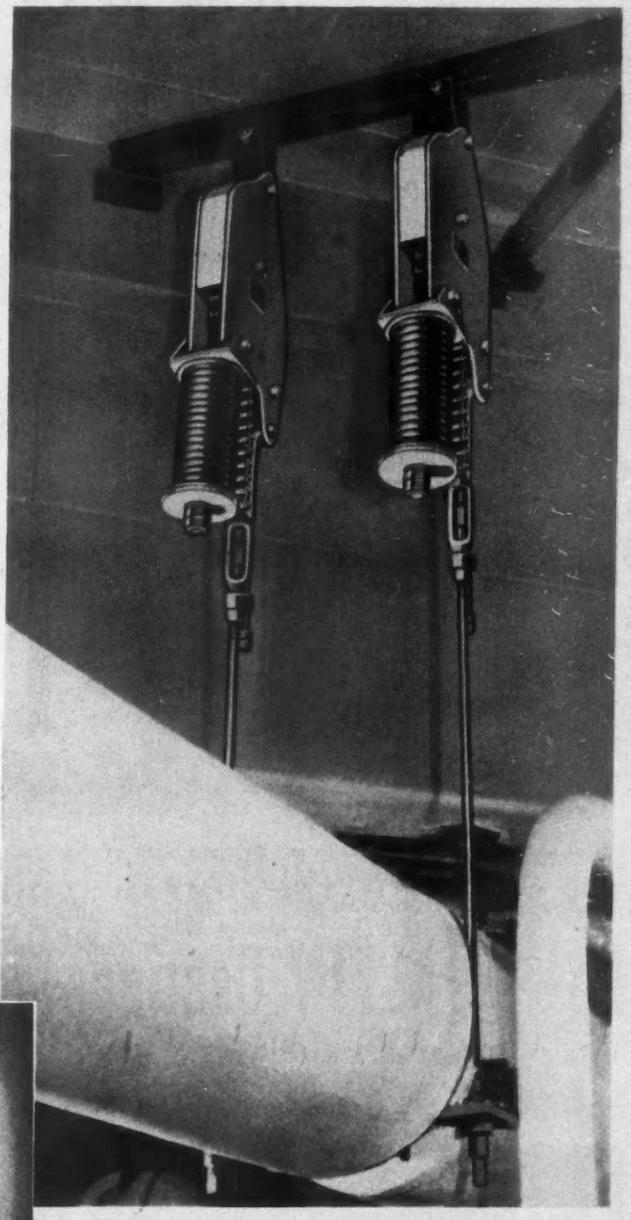
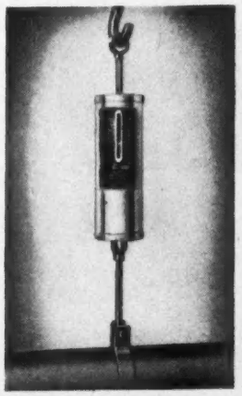
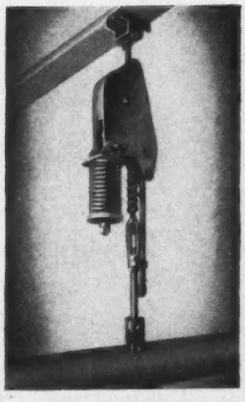
*British Patent Nos.* 474008 720074 720075 697987 657318
*U.S.A. Patent Nos.* 2129320



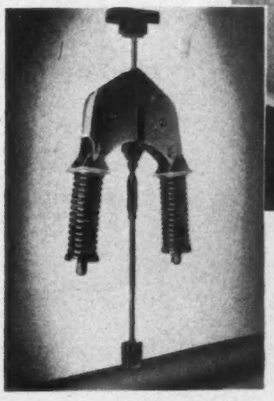
**Ferrybridge " B " Power Station, Central Electricity Generating Board, Yorkshire Division. H.P. Steam pipes supplied and installed by Stewarts and Lloyds, Ltd.**



**Leibfried Red Top Pipe Supports for load from 100 to 5,000 lbs. and total travel of 3″.**



**Conventional type " Con-Ten" Supports for loads of up to 2 tons with a total vertical movement up to 12″.**



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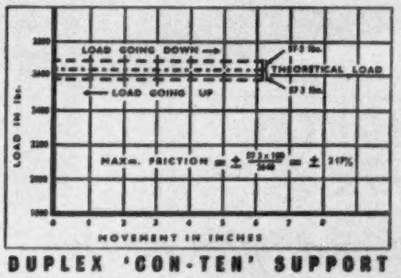
**From graph it can be seen that the maximum friction is equivalent to 2.17% of the applied load.**

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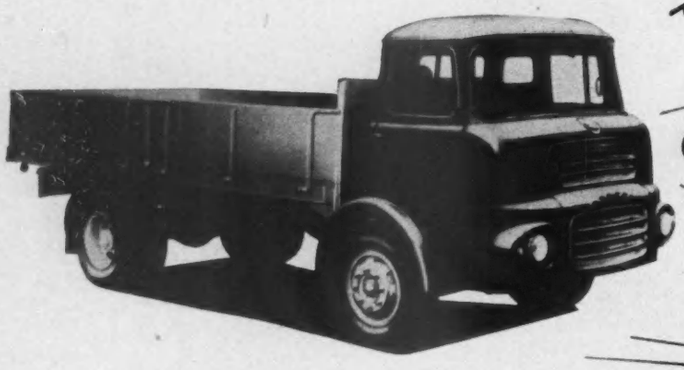

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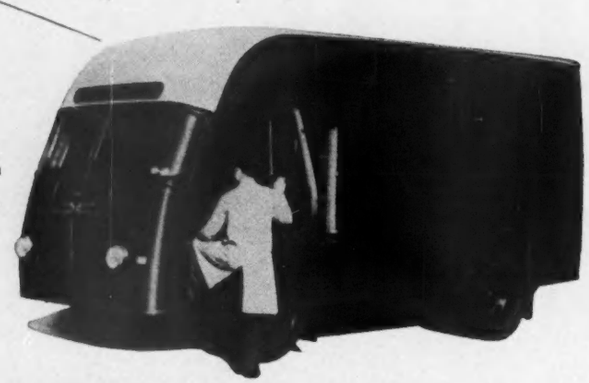

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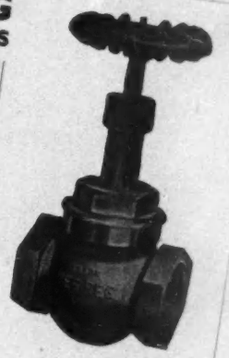

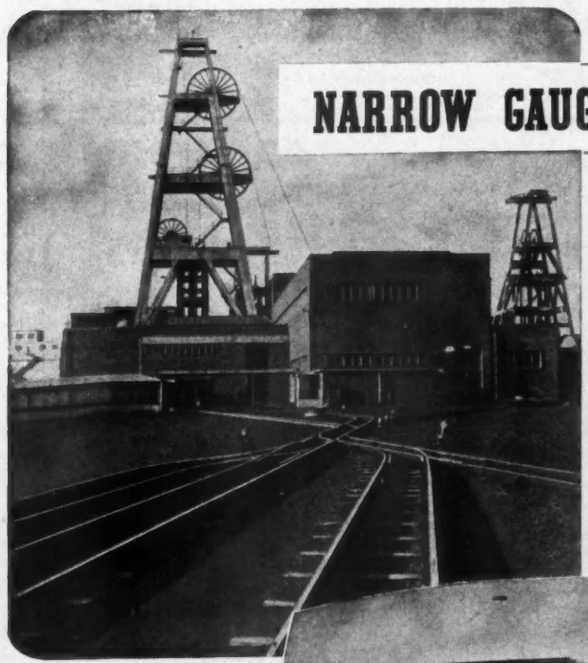

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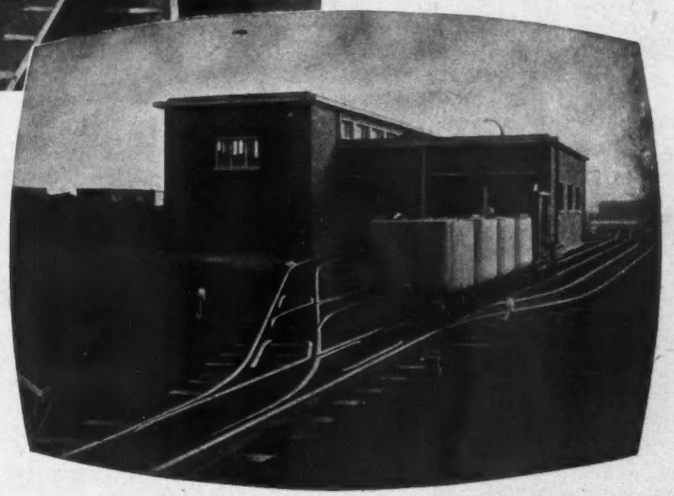

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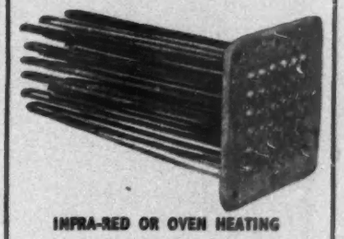

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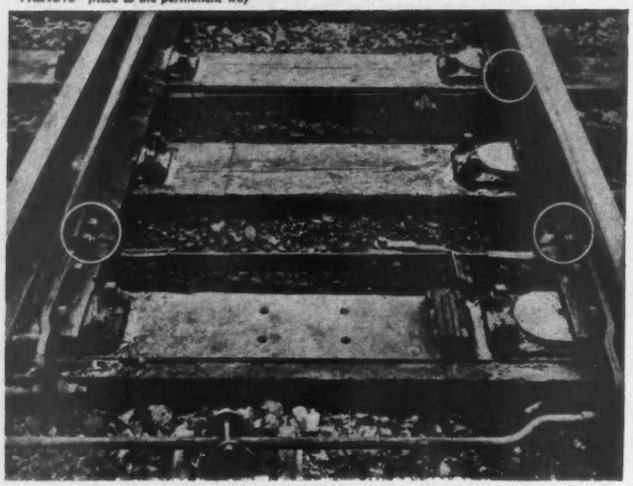

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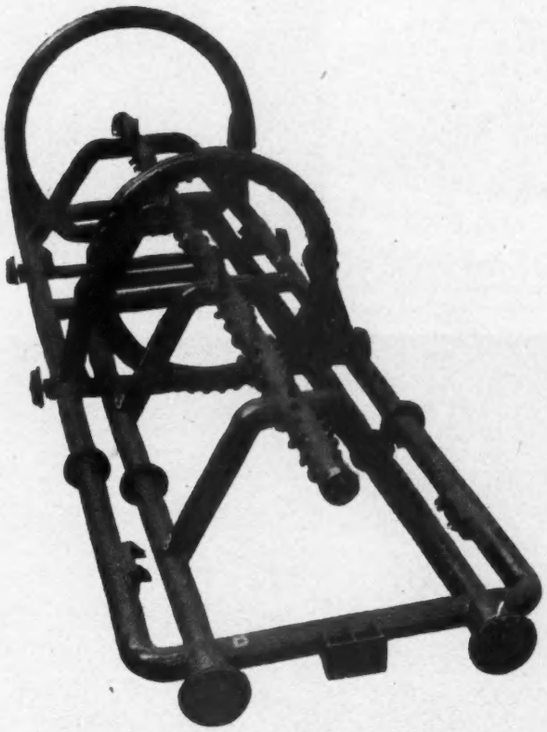

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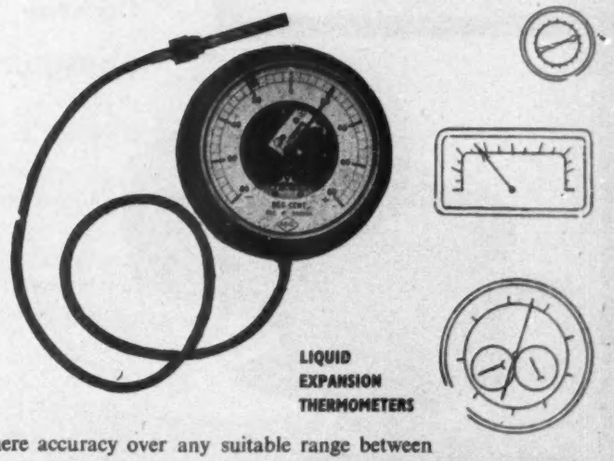

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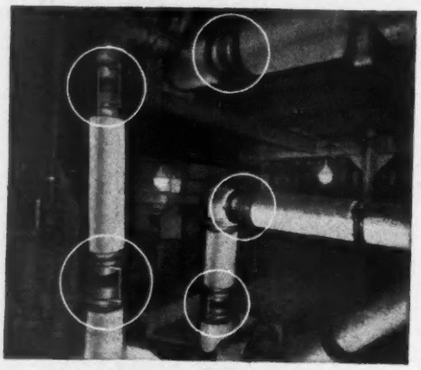

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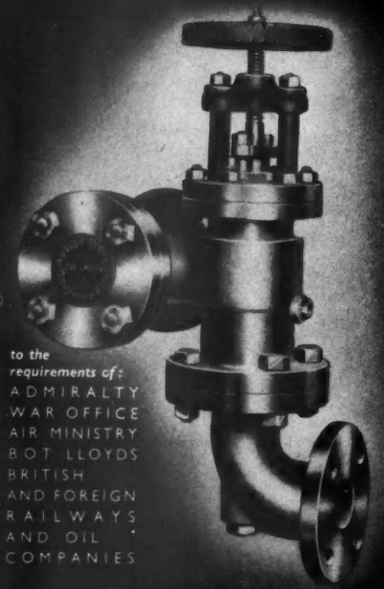

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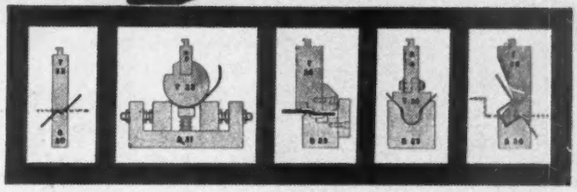

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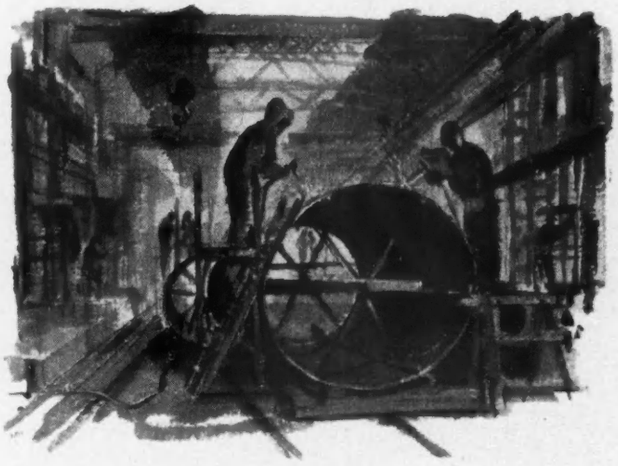

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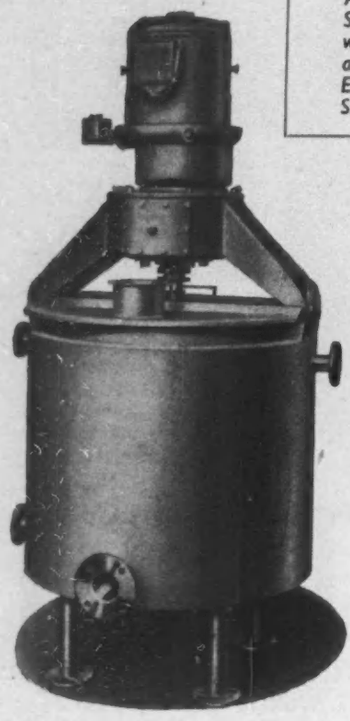

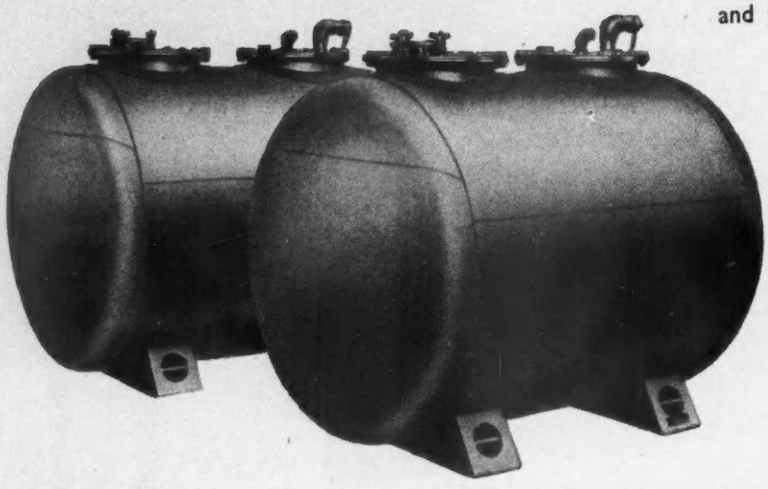

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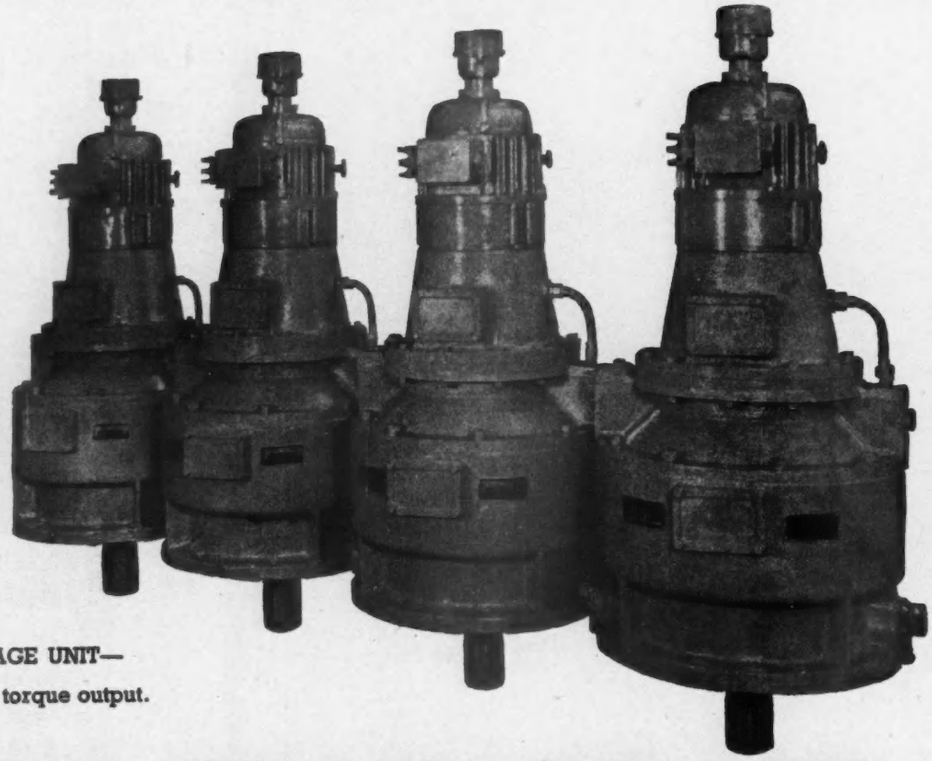

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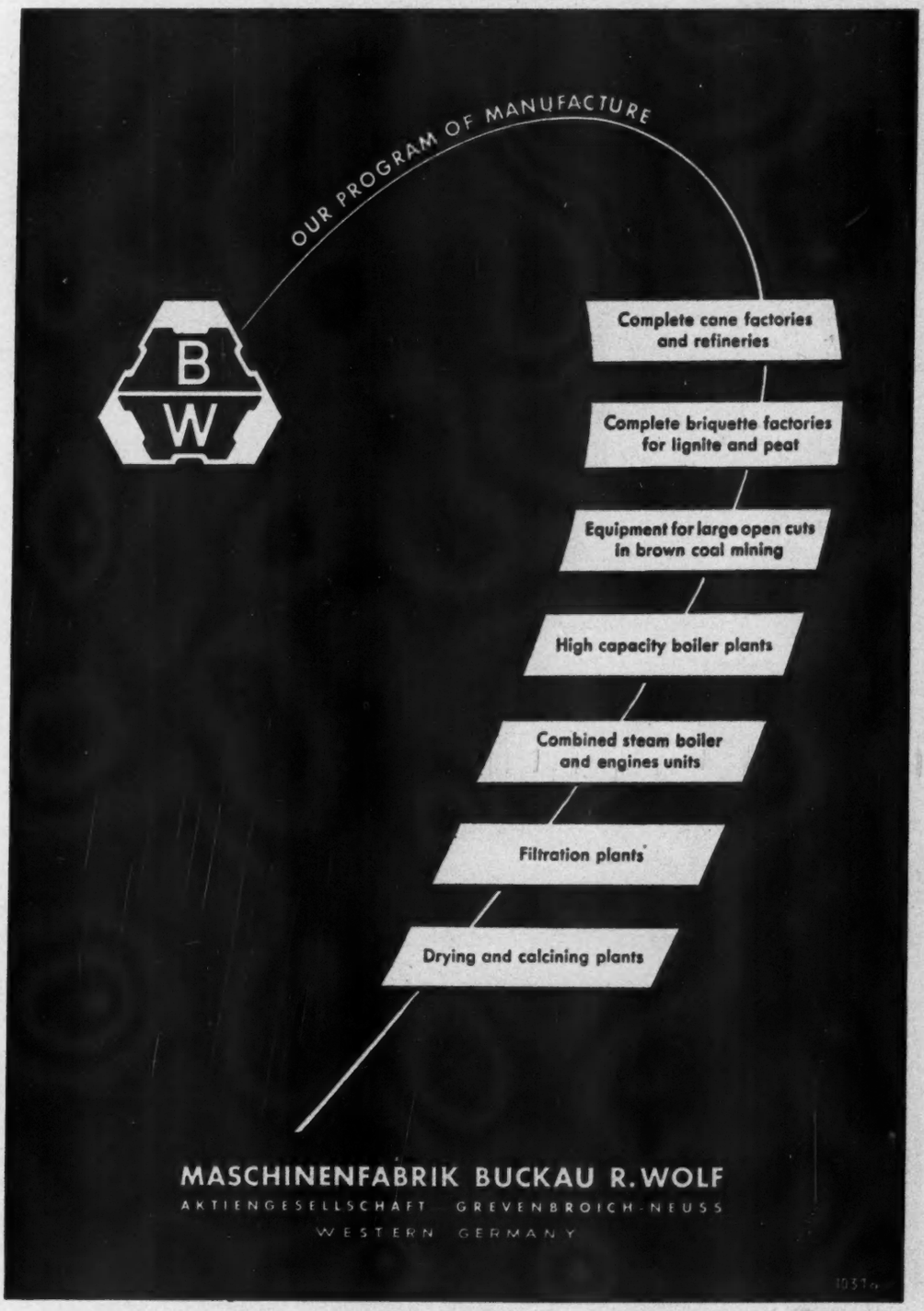
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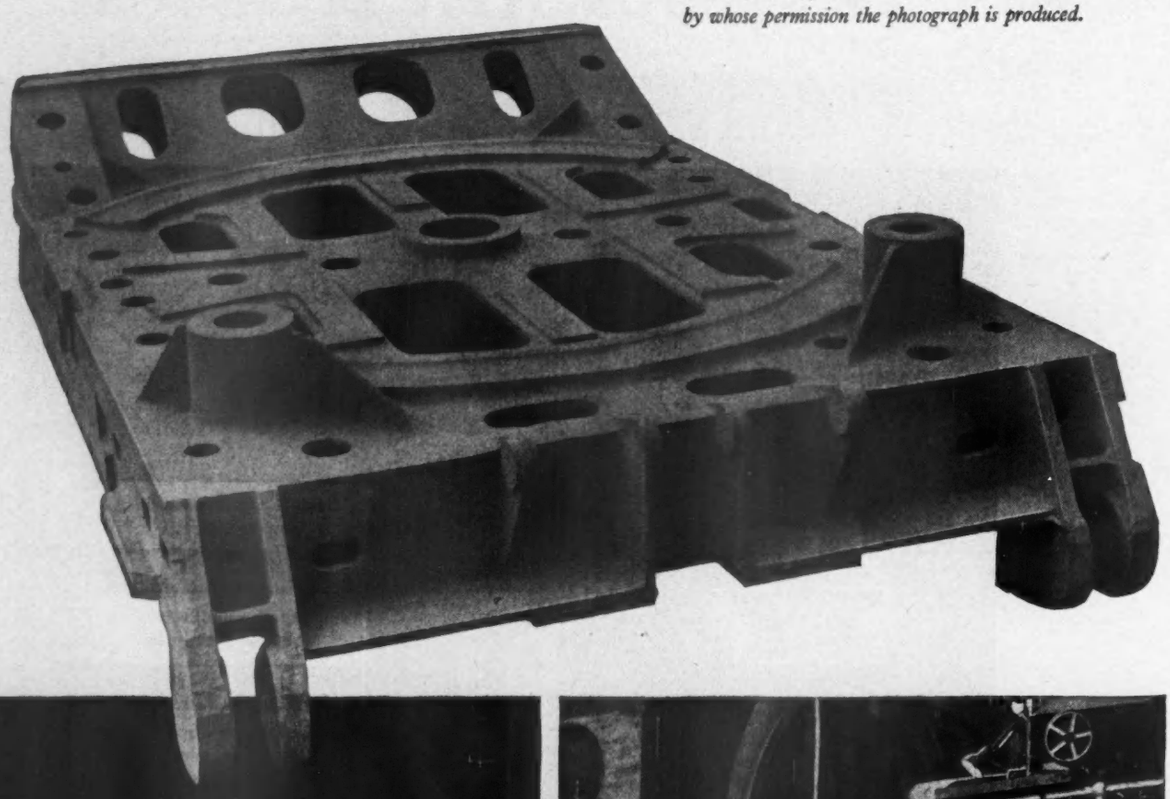
*Revolving frame steel casting for the 150-RB excavator, size 10 ft. x 15ft. 6 ins. Cast for Ruston-Bucyrus Ltd. by whose permission the photograph is produced.*



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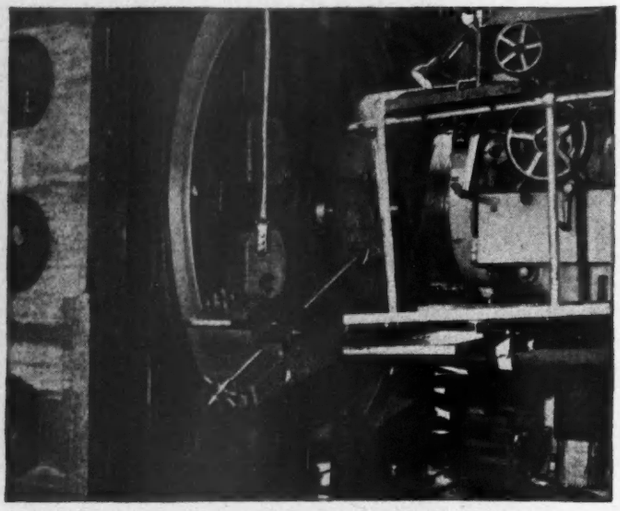

This massive revolving frame is cast in steel for the 150-RB excavator. Weighing 29 tons "as cast" it measures 10 ft. x 15 ft. 6 ins. and is a normal Lloyd production casting. It has to stand up to the severe shock loadings which are developed progressively, as when the 150-RB bites into compacted soil or loose rock that is lifted in one operation. The mould contained 80 cores and there were 21 feed heads. Co-ordinated with the casting was the machining process, a task well within the scope of Lloyds unsurpassed machine shops. The proof of a perfect casting lies in the machining, and it always operates to the advantage of the customer to allow Lloyds to machine the castings they make for him.

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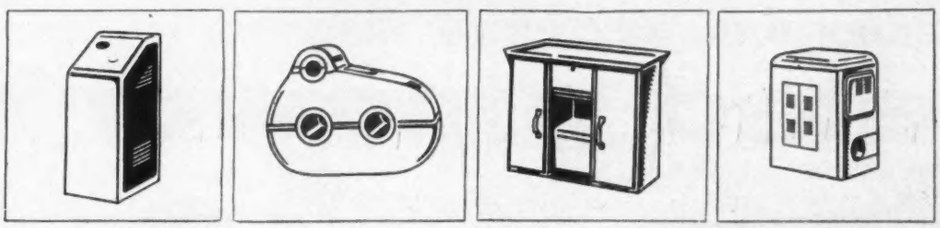

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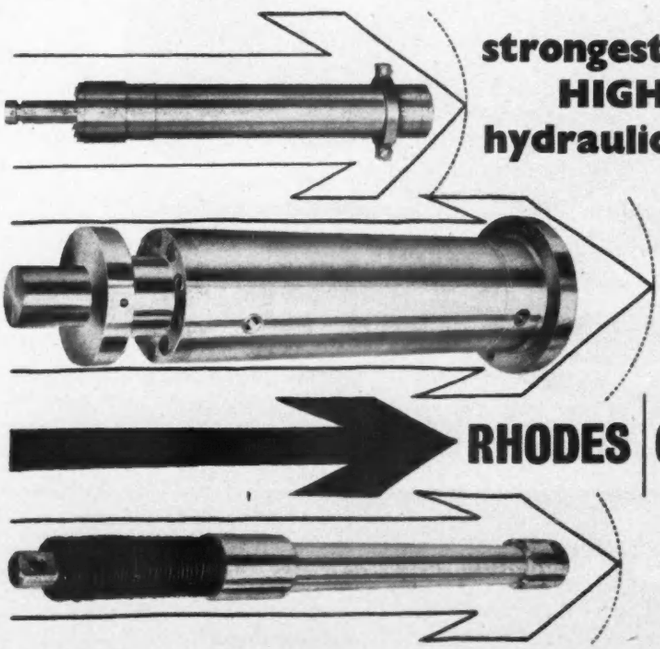

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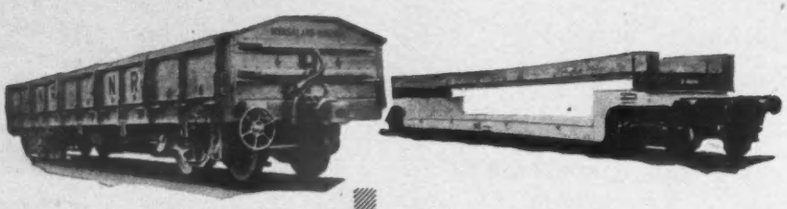

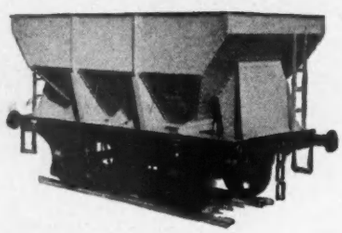

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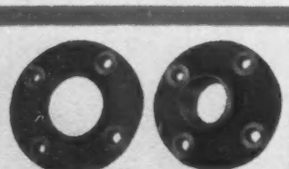

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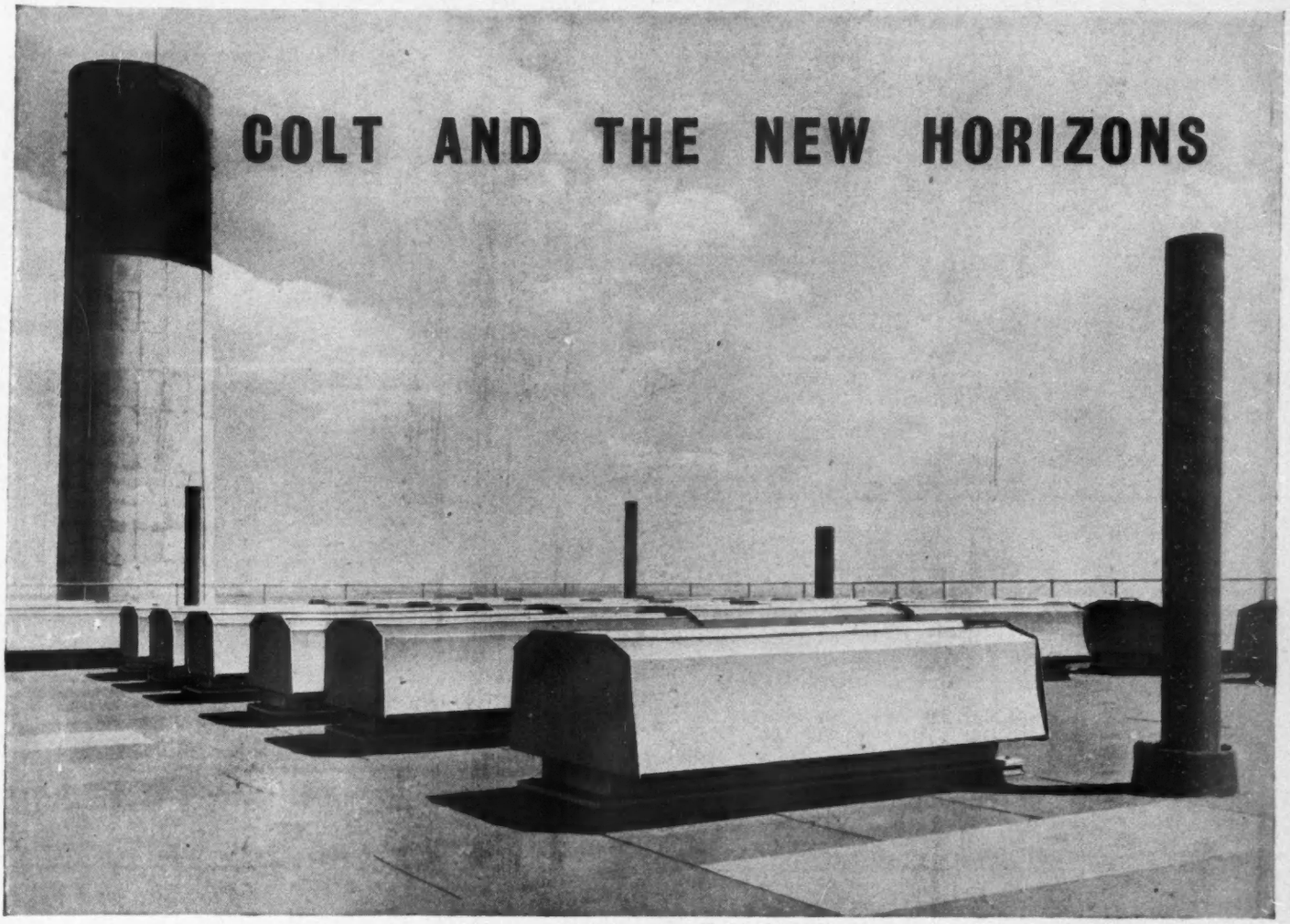


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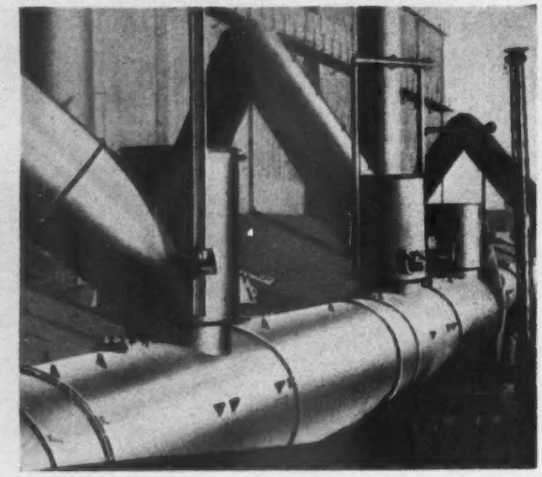

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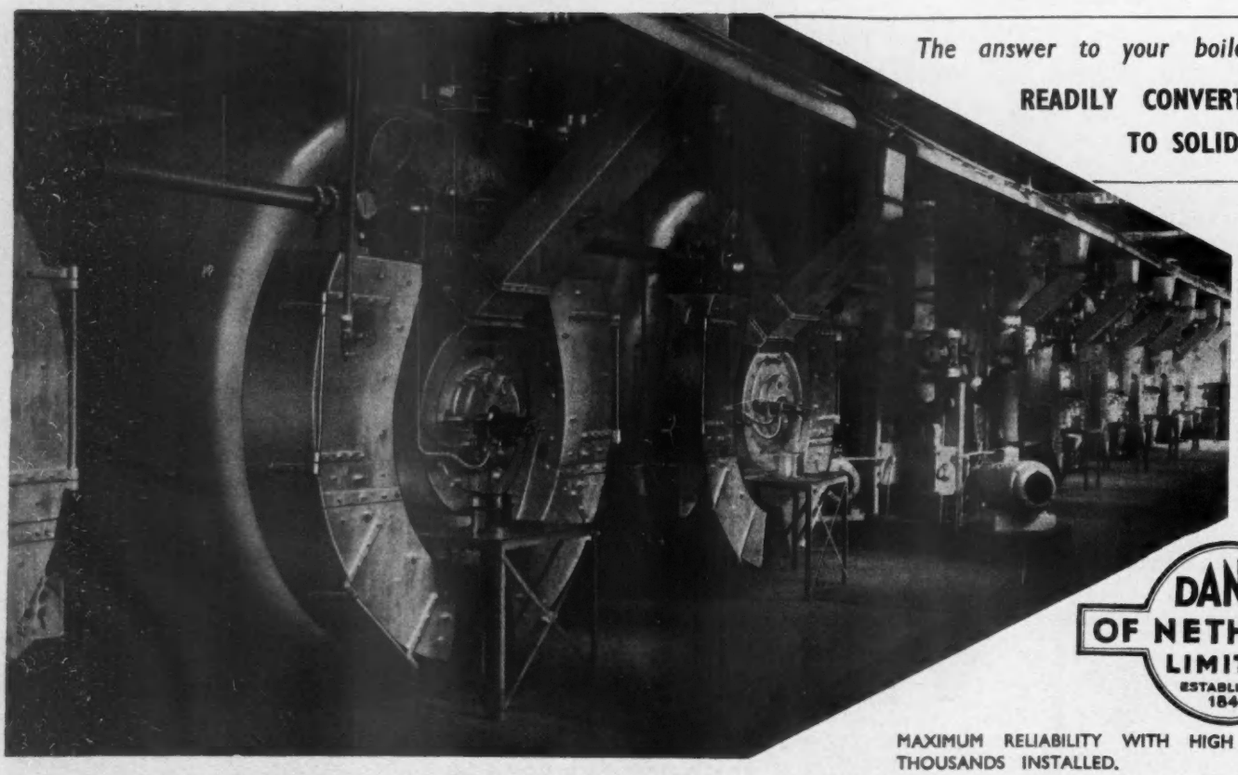

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**READILY CONVERTIBLE TO SOLID FUELS**

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(Patent pending)

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*The construction of the Superloop is fully explained in our Brochure — If you are a user of slings — send for this book.*

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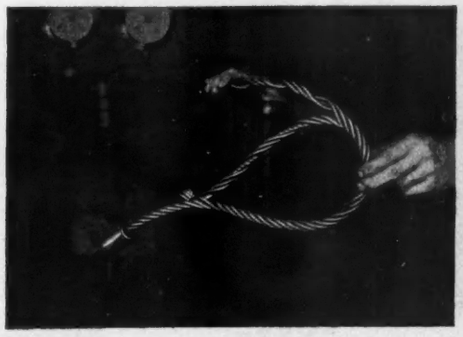
SUPERLOOP in conjunction with Blue Strand Preformed Rope gives you the perfect sling.

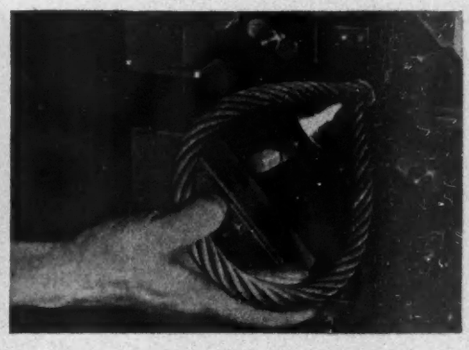


**FORMING THE LOOP**

*The secret of SUPERLOOP's true centre pull — a Flemish Eye is hand spliced and this alone gives a strength in excess of the Safe Working Load even* before *the sleeve is fitted.*

**FITTING THE SLEEVE**

*The steel sleeve is fitted neatly over the tails of the splice and is tapped into place entirely covering the wire ends.*



**PRESS CLOSES THE SLEEVE**

*Specially designed Dies permit comparatively low pressures to be used, eliminating any serious damage due to crushing.*

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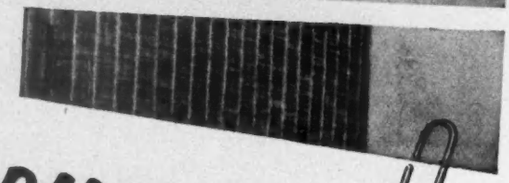

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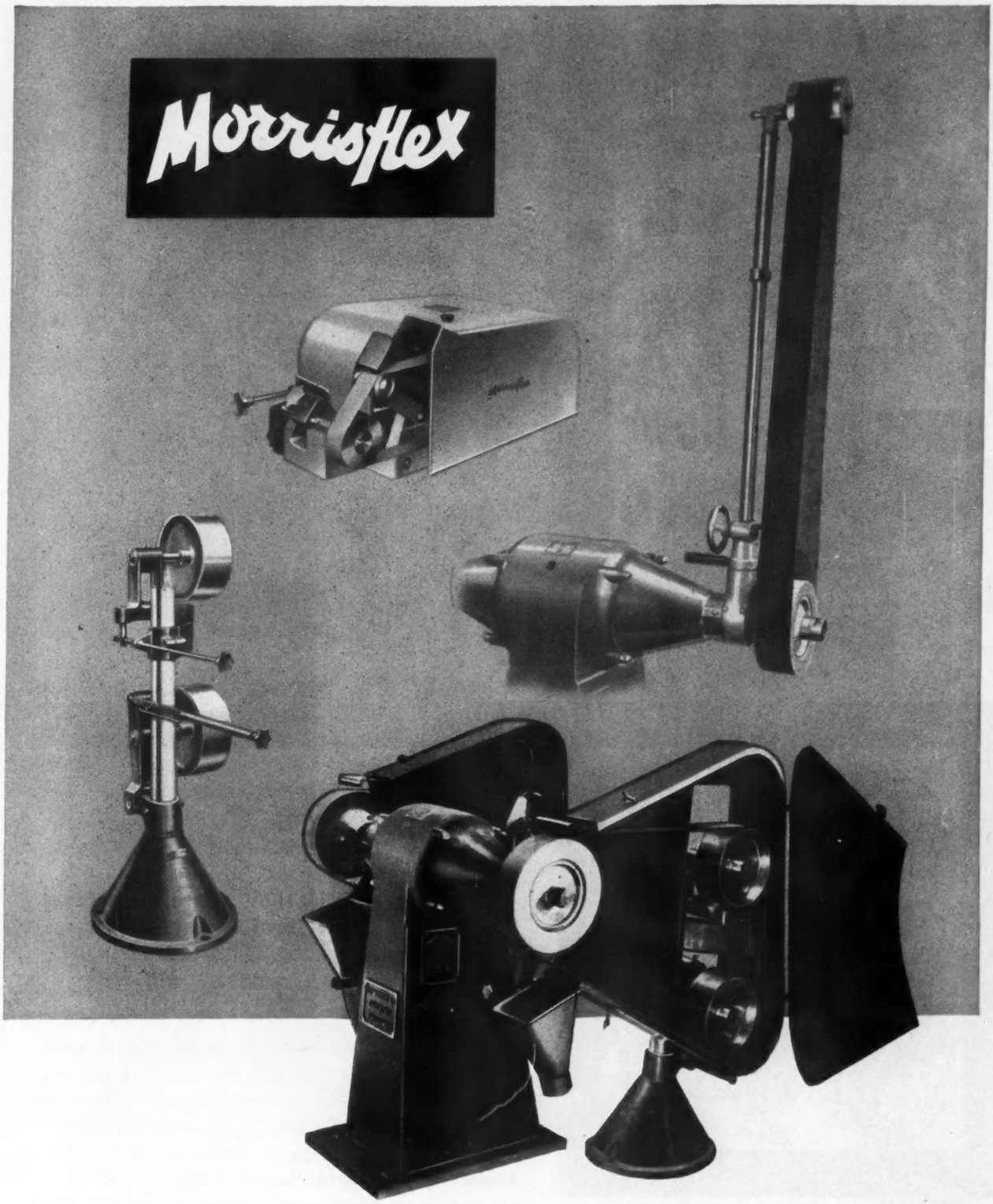


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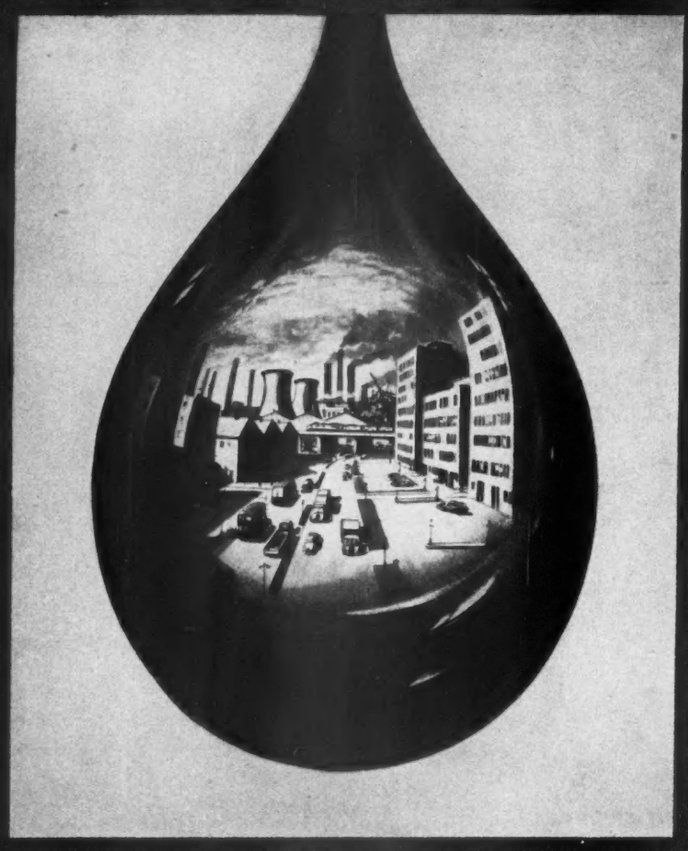

**I understand Ransome & Marles make a special study of lubrication problems?**

We do indeed. A bearing's performance is governed by correct lubrication as much as by correct design and materials. The cage location area is one of vital importance. The lubricant must also protect the highly finished surfaces from corrosion and help to dissipate any undue heat. To fulfil these requirements, we have a team of lubrication specialists at work.

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Research into this is continuous. Operating speeds, loads and temperatures are steadily rising and every week brings fresh problems for solution. Aircraft and guided missiles are the obvious—but by no means the only—instances. Speaking generally we recommend lubrication by oil flood or vapour mist for the very highest speeds. We have built up extensive data on this and allied problems. If you get in touch with our Technical Department they'll be only too glad to talk lubrication with you.

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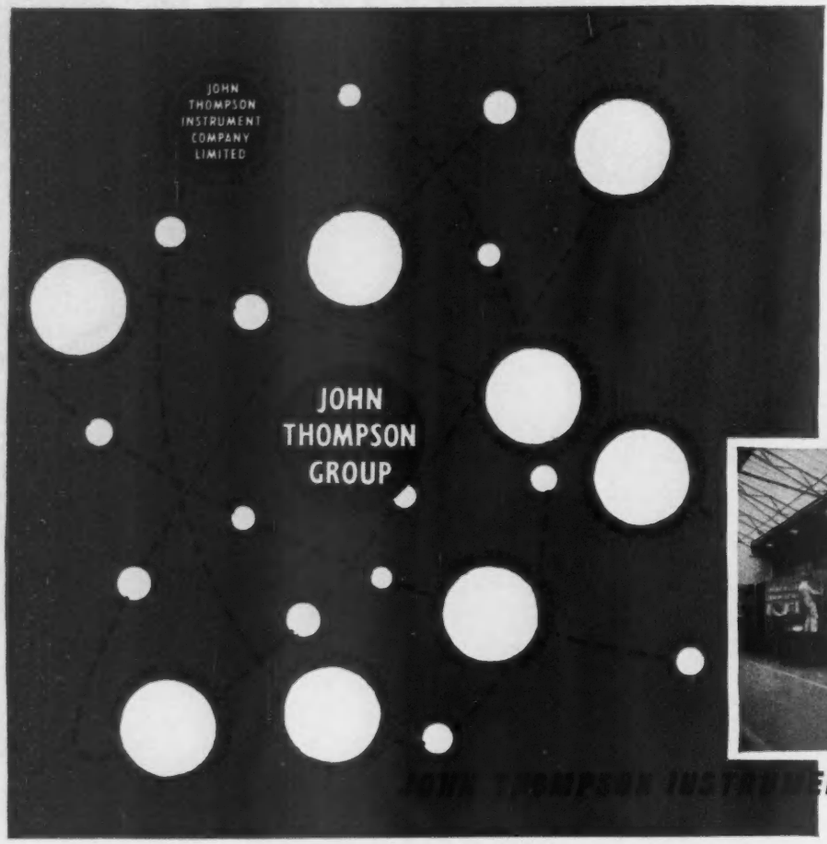


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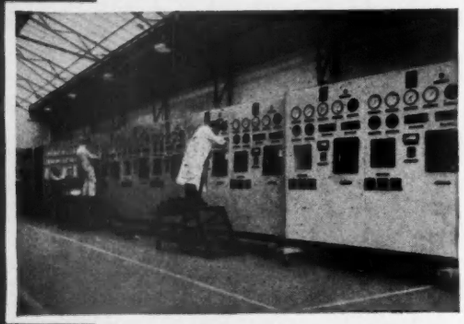

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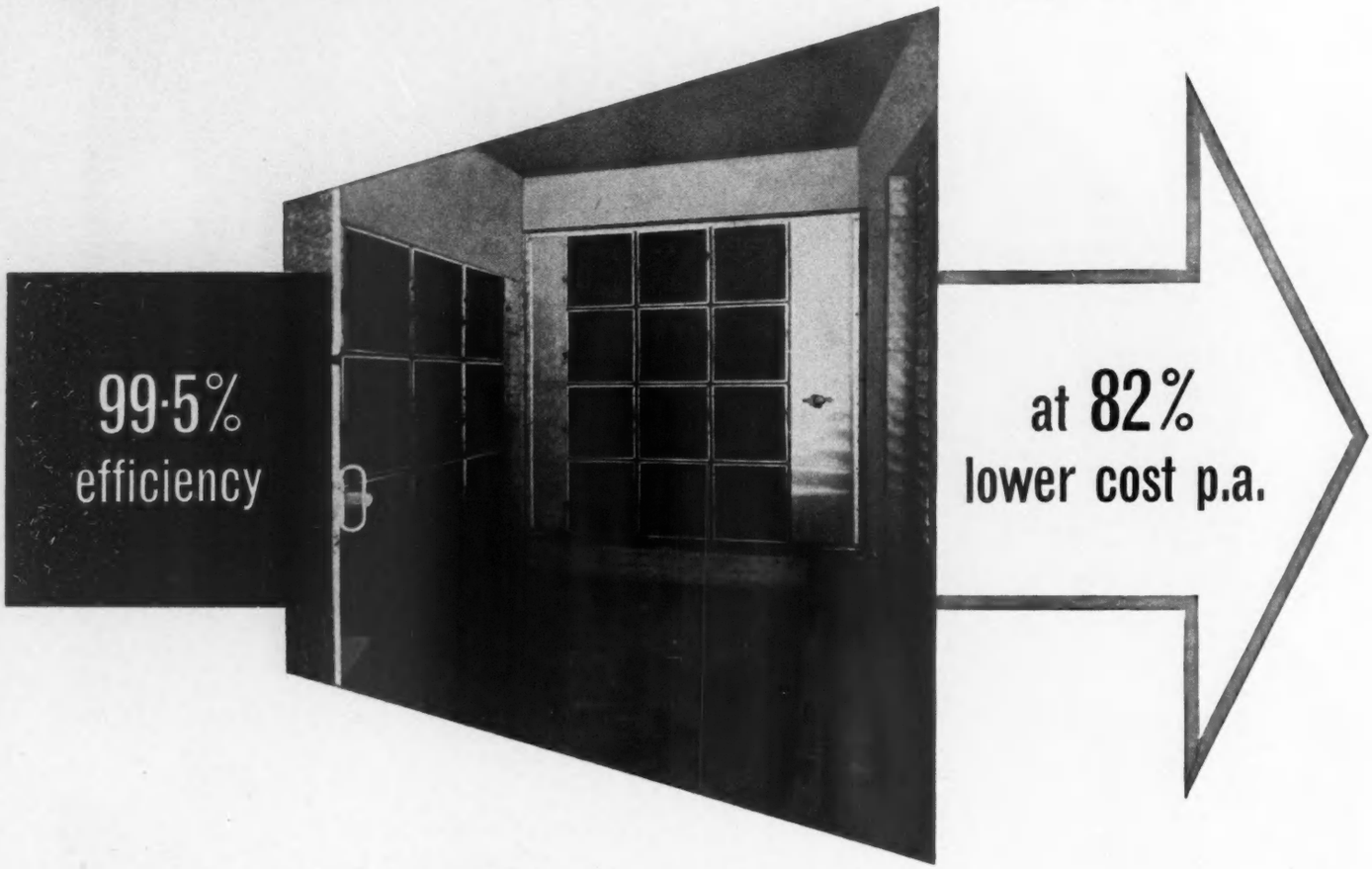


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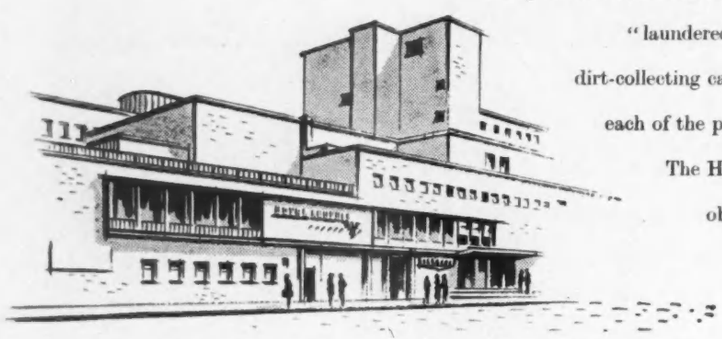

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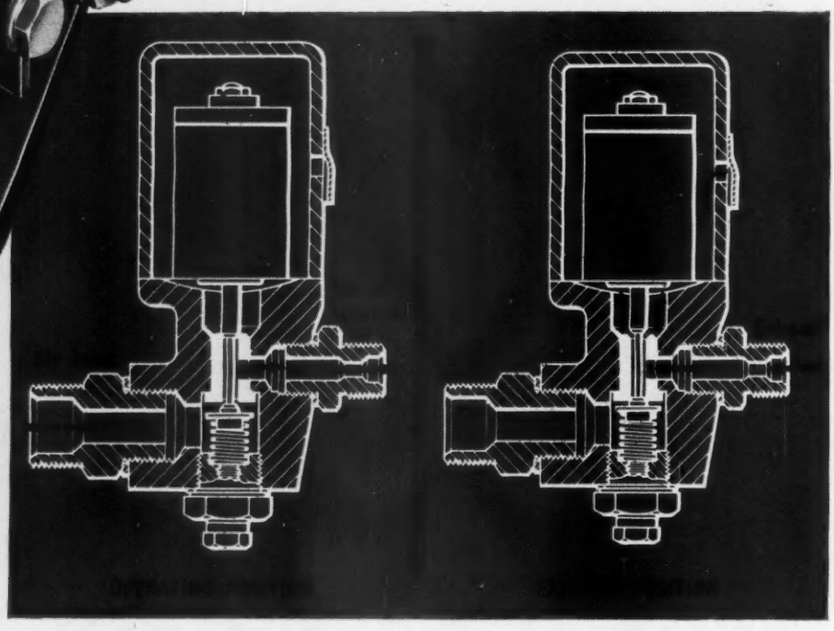

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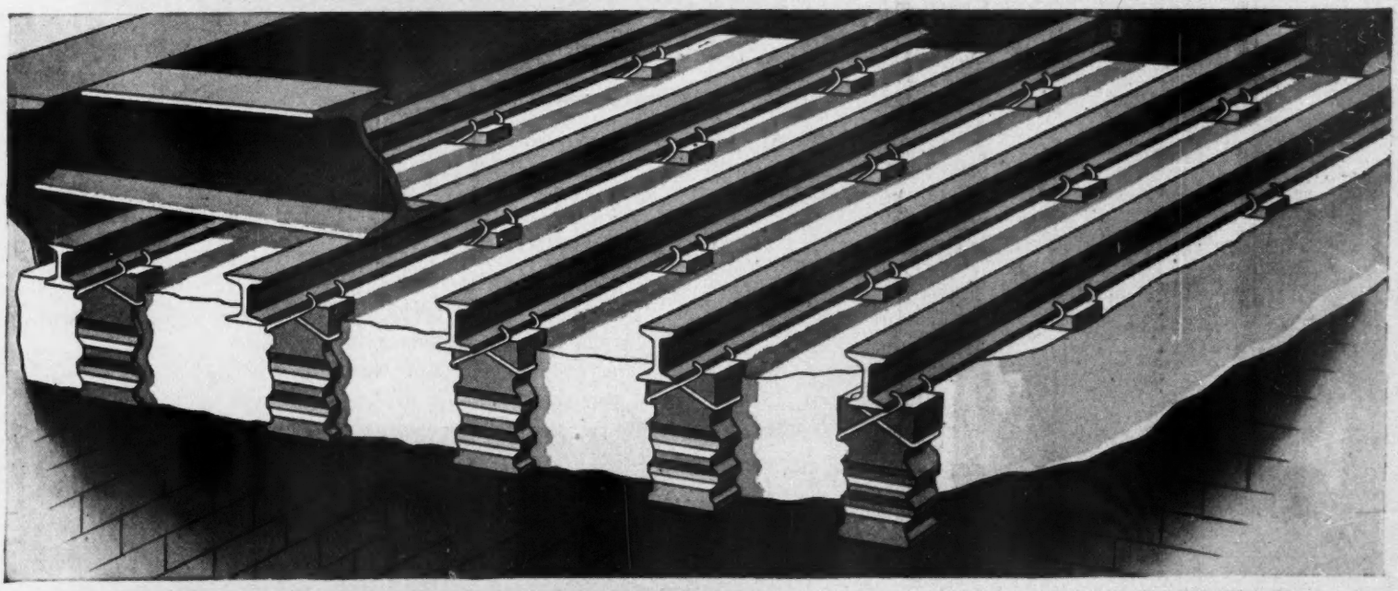

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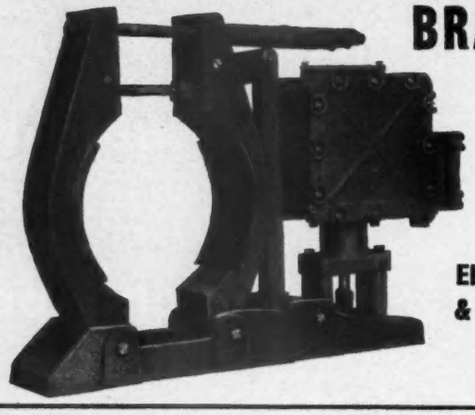

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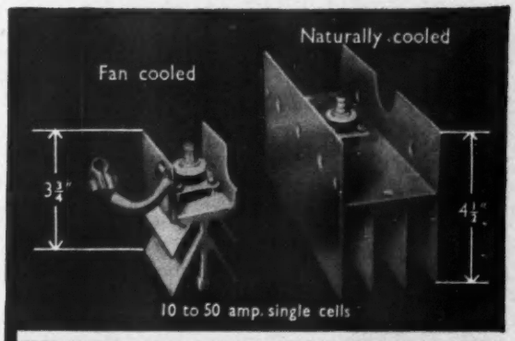

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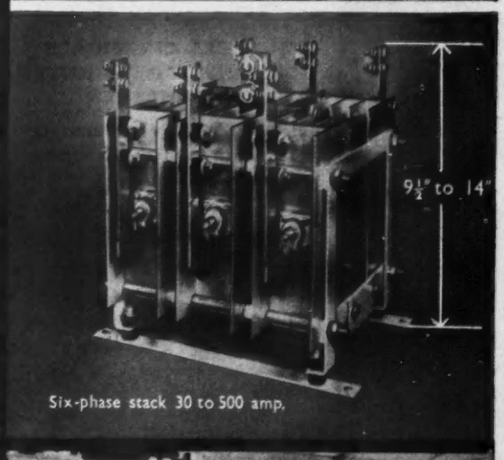

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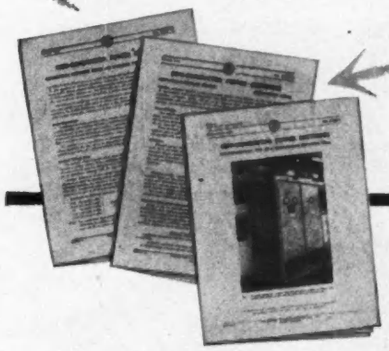

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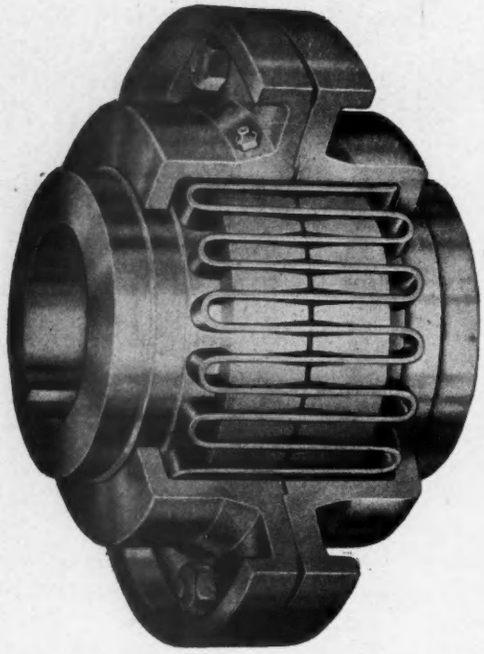

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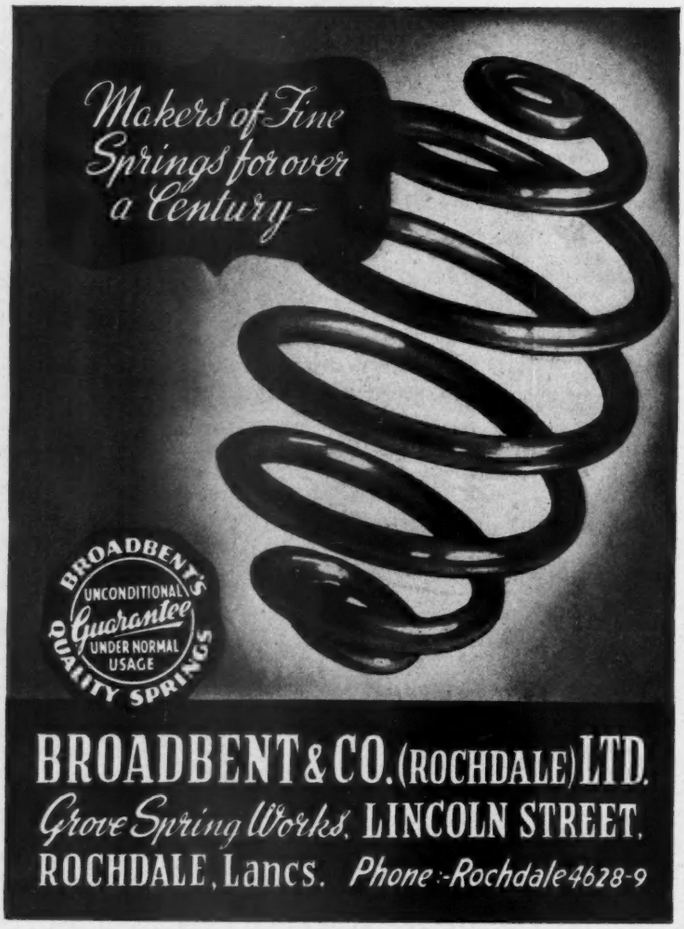


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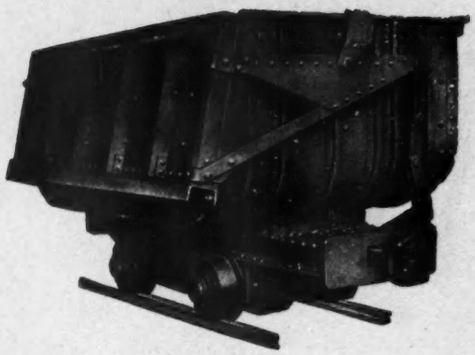

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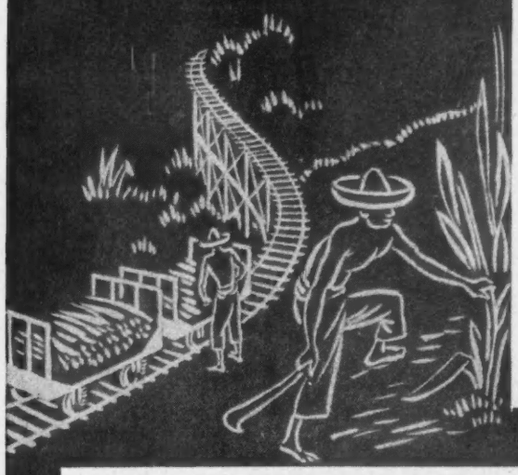
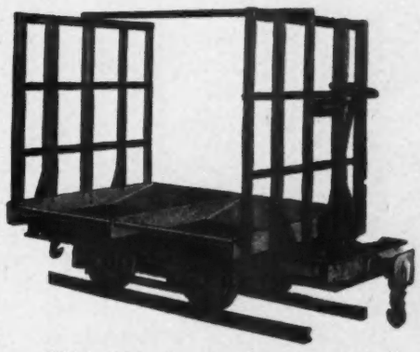
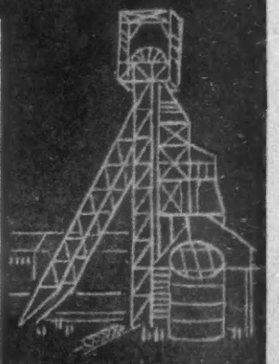




SISAL CAR, fitted with screw brake



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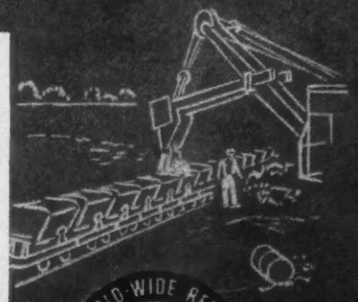

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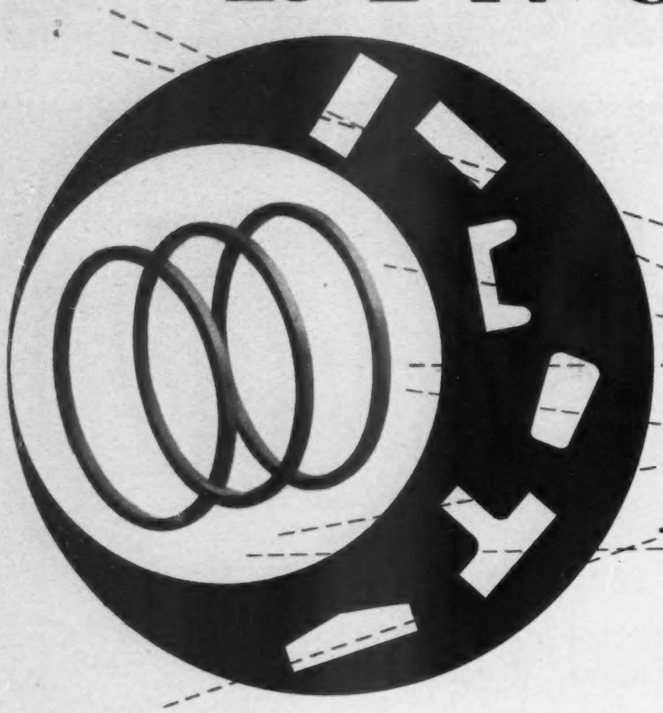

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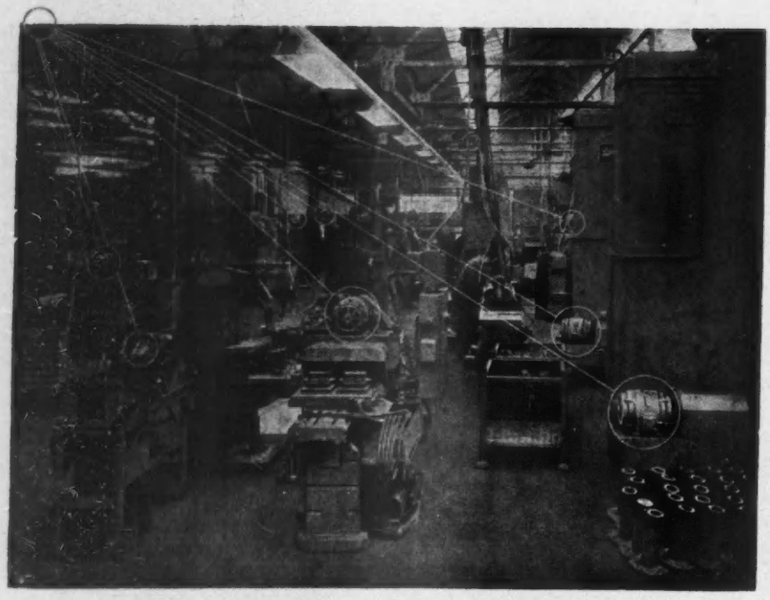

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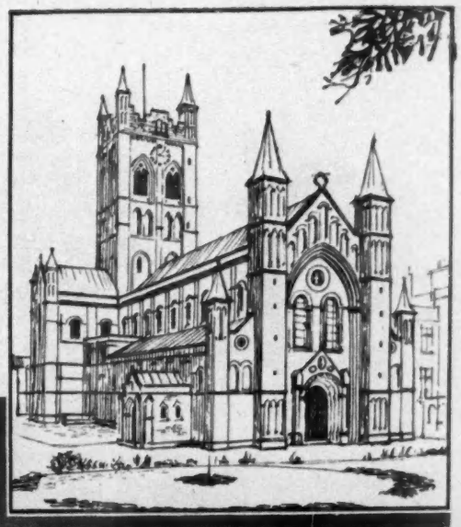

*Architect: J. Douglass Mathews & Partners*

# well-built by

By comparison, this project—H. J. Heinz Co. Ltd., New Food Factory at Kitt Green, Nr. Wigan—is scheduled for completion in September 1958, three years from the commencement date, and has employed an average of 650 operatives throughout. Once again Monk, one of Britain's foremost Civil Engineering, Reinforced Concrete and Building Contractors, have been entrusted with the task.

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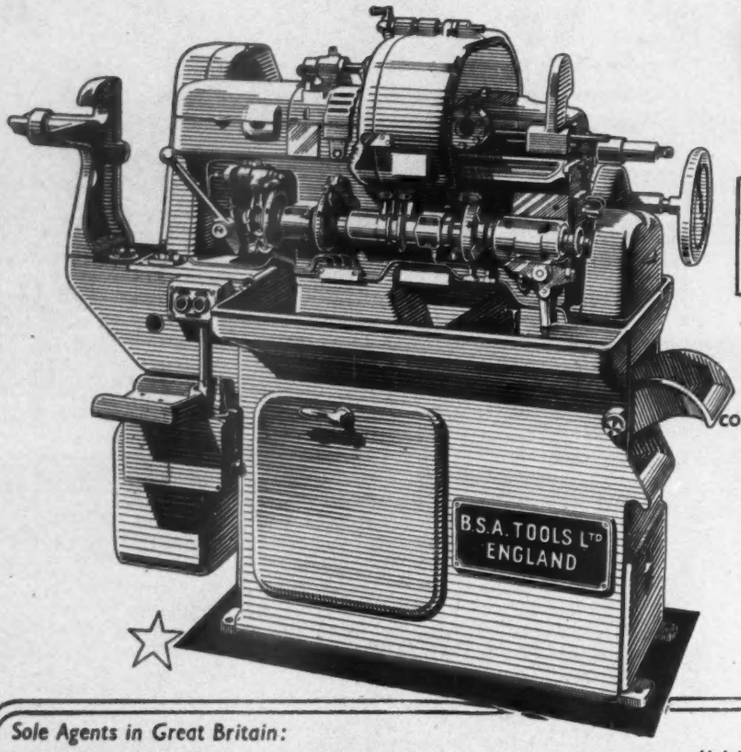


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# THE ENGINEER

No. 5345 JULY 4, 1958 VOL. 206

## IRON AND STEEL INSTITUTE ABROAD

The Iron and Steel Institute has for very many years been internationally minded and, indeed, nowadays a substantial fraction of its membership is made up of foreigners. Regularly in the summer months, usually at two years' intervals, it takes its members abroad to see how steel and steel products are made in other countries. This year the members spent the days between June 17 and June 28 in Belgium and Luxembourg, visiting firms in the neighbourhood of Liège, Luxembourg and Brussels and Charleroi. Since the visit was organised to correspond in time with "Journées Internationales de Siderurgie 1958," which were being organised in those two countries, the affair became fully international and rather more technical sessions than are usual at Iron and Steel Institute Summer Meetings were held. Close upon 1200 people must have registered for the meeting, though not all of them attended visits and technical sessions at all three regions. The handling of such very large numbers of people would have presented a difficult problem at Liège and Luxembourg but for the fortunate fact that at both places great Palais des Expositions are under construction and that both buildings were sufficiently advanced (their states of incompletion masked by the hanging of flags, fabrics and curtains and the laying of carpets) to be used as headquarters and for the technical sessions and other functions. The comment was made, however, how astonishing it is that a provincial city such as Liège can find it worth while to erect such a building housing three meeting halls accommodating 250, 500 and 1000 people, restaurant capacity to correspond, and large exhibition spaces as well, and that Luxembourg can find uses for a building not very substantially less large. One must suspect that the Belgians and Luxembourgers have it in mind that the coming into being of a Common Market in Europe must lead to the more frequent holding of great international gatherings and there may be a hope that if the Free Trade Area proposals fructify Belgium may come to be regarded as the centre for international discussions, even if Brussels does not itself become a centre for the Area's international organisations.

Always at Iron and Steel Institute meetings abroad particular interest is taken in the visits to works. In countries less well-endowed with iron and steel plants the net is widely spread to include visits to foundries and engineering works and to power stations and the like. But in Belgium and Luxembourg the choice for visitors lay each day rather between the competing attractions of differing steel works or mills than between a steel works and some other kind of plant. Nor, because of a peculiarity of the industry in Belgium and Luxembourg, was it possible to choose between plants known to be modern and plants known to be of some age. For rebuilding is taking place piecemeal and few, if any, plants are being erected on green field sites as they are in this country. Thus, in going round a works one might encounter continuous strip mills so right-up-to-date that they only came into regular production a few months or even weeks ago and elsewhere, in the same works, find rod mills of the old spectacular kind in which men with tongs dexterously catch the rod as it emerges from the rolls, swing a red-hot loop of it behind them and insert the end into the next pass. In one works we observed a heavy blooming mill driven by a great four-throw horizontal steam engine exhausting apparently to atmosphere and developing probably as much as 1000 h.p., whose name-plate bore the date 1899, and in the same works found a very impressive new melting shop approaching completion which will have five 50-ton converters and three 1300-ton mixers and two electric furnaces for melting ferro-manganese. The converters are to be blown with air enriched to 26 or 30 per cent oxygen. Similarly, advanced techniques could be observed applied in plants in other respects far from modern. Vacuum casting, for example, was observed at one works, desulphurisation by the addition of soda-ash at another. Everywhere, seemingly, the evidence was available of the consequences of the modern availability of tonnage oxygen which has in many respects revolutionised steel works processes.

Technically and internationally there can be no doubt of the success of the meeting. But socially we confess we thought it less satisfying than other meetings the Institute has held since the war. For the meeting was over-large, so that each individual attending was acquainted with a lower-than-usual proportion of those present. Furthermore, both at Liège and Luxembourg, it proved necessary to spread members over hotels into places at some distance from the centre, as far out as Spa in the first instance, thus breaking up the meeting into groups. In addition, sheer weight of numbers limited the freedom of the Institute's various hosts to invite members to attractive receptions and other functions in buildings of particular interest. In such circumstances there always follows the unsatisfactory choice either to limit all such functions to buildings capable of holding the whole membership or, as on this occasion, to arrange a social programme within a social programme, that is to invite only the selected few to certain functions not open to the rest, and accept the invidious business of selection thus entailed. Some heart-burning necessarily results; and, more importantly, for some members a certain distinction of character that Iron and Steel Institute meetings abroad have had, tends to get lost. For women folk in particular the point is important. But it does not lack importance for the men because it is at these social functions that the ladies, so much more easily than the men, become acquainted and thus draw their men-folk together.

## CONSERVATIVES AND KILL-JOYS

Considering the material benefits that have been conferred upon mankind through the work of engineers it is really very remarkable how much opposition these engineers often have to meet before their beneficial work can be done. At times that opposition becomes especially vocal. Let it but be proposed, for example, that a dam be built across a valley in Wales or that a nuclear power station be situated upon a lonely length of coast and many worthy people will gather together to oppose the proposition tooth and nail. They may have some justification on their side, too ! For there is no proof that increased material wealth has increased human happiness. But most of them argue on a less credible line. They argue that the works of engineers " desecrate " nature, that in fact " Where every prospect pleases only man is vile " ; overlooking that in this country, as over most of Western Europe, the scenery (apart from contours) is either all man-made or man permitted and that if nature is allowed to run really wild it often produces some pretty horrid results ! Thus to assume that the intervention of engineers must lead to a desecration of nature is nonsense. Much more reasonable are those who in offering opposition are seeking not to prevent the carrying out of a work, but to ensure that when carried out it will add to the beauty of its surroundings and do no damage to amenities.

Often, however, the opposition is much more subtle and much more effective. Instead of suggesting that all the works of engineers are necessarily ugly, and that they necessarily desecrate the countryside the more subtle opponents of change suggest that there would be something a little immoral about doing what the engineers propose. For there still persists in this country some thinking upon Puritanical lines. It still seems to many, for example, that there is something vaguely improper about expending money solely to increase human pleasures. It is very possible that it is this kill-joy element in the mental make-up of many people which has led this country to fall so far behind almost every other industrialised country in building motor-ways. The official governmental explanation since the war has been that the country could not " afford " to expend money on its roads. But other nations no better off than ours have managed to " afford " it without difficulty. A more likely explanation is that there has always been and there still persists in this country a quite strong opposition to motor transport. It is based upon the idea that motoring is a pleasure and a luxury and hence that it would be improper to spend much money upon it. Thus the fact that upon every fine summer week-end around London and other large cities traffic conditions upon the roads become intolerably frustrating to the pleasure motorist, becomes ineffective as an argument for improving the roads. For it will be felt improper to expend money merely to increase people's pleasure ! When, however, it can be shown that road improvements yield substantial economies for lorry traffic and for those who use their cars for business purposes opposition ceases. " Life is real ; life is earnest." If expenditure upon the roads will permit us to work harder then it becomes permissible !

But, of course, the trouble with this innate feeling that no encouragement should be given towards the development of things pleasurable or luxurious is that it almost inevitably offers opposition to engineering advances. For obvious reasons no new thing engineers produce can ever be immediately regarded as a necessity. Whilst it is in short supply it is a luxury. Particularly is it likely to be regarded as a luxury if it is labour-saving like a household vacuum cleaner or a washing machine, &c. For then it is taken to pander to those who are lazy good-for-nothings! Only when very substantial numbers have been sold does the new thing come to be regarded as a necessity and hence an entirely proper thing to have. But in the meantime national and local government, not to speak of various other bodies, may have regarded the product with dislike, granting the manufacturer no favours or even attaching to the product some form of sumptuary tax. It is, no doubt, because many people still regard the owners of cars as " idle rich " that the Government is able to retain a 60 per cent purchase tax on vehicles and a heavy tax on petrol !

## BRITAIN IN EUROPE COMMITTEE

At the moment no one in industry or even in politics can quite know what the situation is about the advent of the Common Market in Europe or the chances of the creation of a Free Trade Area around it. Political events in France, some of whose industrialists showed little liking for the Free Trade proposition, and whose national economic situation does not even favour as rapid a development towards the Common Market with the Benelux Union, Western Germany, and Italy, as was originally hoped, have temporarily popped everything in the melting pot. Yet, in our view, which we believe to be supported by the majority of economists, there is so much good sense in getting rid of customs duties and other impediments to trade over the greater part of Western Europe that the Common Market, to the formation of which France is already bound by treaty, and the Free Trade Area are certain to win acceptance very soon in some form. It is therefore welcome to find that a new industrial organisation is to be formed in this country to be called the Britain in Europe Committee. Particulars of the Committee were reported on page 985 of our last issue. Its main function will be to undertake or sponsor original research on European economic integration, especially about the proposed European Free Trade Area and to make known the results and it will also provide specialised information.

For certain British industries no such new body is at all needed. The iron and steel industry of this country, for example, keeps in such close contact with the corresponding industry on the Continent that its technical people are as aware of the economic situation and of technical progress at any plant there as of similar progress in Britain. As we record in another note on page 1, the members of the Iron and Steel Institute have, for example, just returned to this country from a special meeting held in Belgium and Luxembourg. There is even joint international research as, for example, at Ijmuiden into problems of interest to the industry. But in the engineering field there are certainly large numbers of firms in this country which have little or no knowledge of Continental methods of production or even about its scale and which would be very hard put to it to determine with any degree of precision what effect the creation of a Free Trade Area would have upon their prosperity. The more is it a pity that once more this year the Institution of Mechanical Engineers failed to hold its Summer Meeting abroad, successful though its Cardiff meeting turned out to be. For one of the objectives of the Committee, " to promote an understanding in industry in general of the issues likely to arise from British participation in the European Free Trade Area and to link this understanding with the

industries in the political sphere necessary to secure satisfaction of the appropriate treaty or convention" would certainly be much aided were more British engineers aware of Continental conditions. Indeed, engineering is not, we feel, as strongly represented on the new Committee as it should be.

## ACCESS TO THE CAPITAL

Now that London, in common with other great cities such as New York, has more than one airport for international flights, it is no more than timely that a helicopter station should be established near to its centre. Helicopter travel between London airport and Gatwick, invaluable as it would be to a small number of through passengers, could hardly be sufficient to support an air taxi service, but there should be many travellers who, after the cushioned swiftness of an airliner, will reject the dilatory dawdle of a coach or the harsh hammering of a train for the final approach to the capital. It is, therefore, most welcome that Westland Aircraft, Ltd., should have secured the necessary consent from the local, metropolitan, ministerial, planning and port authorities to risk its capital in the construction of a helicopter station on the Surrey bank at Battersea. It is to be hoped that the many hurdles of air traffic control, customs attendance, provision of fuel, and so forth, will be overcome in their turn, and that this venture will act as a catalyst to initiate municipal helicopter stations in other cities and perhaps even in London.

It needs to be clearly recognised that this establishment has come about in default, rather than by virtue, of an official policy for the provision of flying facilities for the capital. The authorities concerned allowed the experimental station at the South Bank to be closed—although it must in fairness be stated that they have not prevented its subsequent use by, for instance, Helicopter Sales, Ltd. —since, in the absence of multi-engined aircraft that could carry a break-even load under the various restrictions imposed, the operators of public services had no use for it. It is necessary to note that this occurred before any alternative site for the machines of to-day had been investigated and found satisfactory, and that it is merely providential that one or two potentially suitable places were found near Battersea. Such good fortune should most emphatically be regarded as exceptional and not be expected to prevail in, for instance, the provision of conventional flying fields. For this reason we deplore the apparently undisturbed equanimity with which the Minister of Transport and Civil Aviation contemplates the anticipated closing of Croydon Airport. The existence of a helicopter terminal does not render a small aerodrome valueless—not only might it be useful as a park and maintenance base for V.T.O.L. machines, but it appears that for rather longer stages, or for the ability to operate more cheaply, S.T.O.L. aircraft will establish themselves and be valued by visitors to London.

## SETBACK AT CALDER HALL

In a world that is sharply conscious of both the enduringly injurious and the instantaneously catastrophic consequences that can ensue when atomic nuclei break up, even the smallest incident connected with the study or application of nuclear energy may draw the alarmed gaze of the public. It is particularly unfortunate, therefore, that an accident to a turbo-alternator should have occurred at the Calder Hall "B" station. At about 7.30 p.m. on Saturday there was a failure in No. 5 set which caused fairly extensive damage to plant, but luckily neither killed nor maimed anyone. Apparently some fragments of the set were hurled for more than a quarter of a mile, and parts of the turbine hall were wrecked. All this happened as the climax to running tests that were being imposed on the particular set. It was officially stated that no increase in radioactivity had been observed, so we may presume that, even if some part of the coolant circuit was punctured (which seems at first sight not very likely), no burst slugs were noticeably contaminating any gas that may have escaped.

Had the accident occurred in a conventional steam station the lay press would have taken not very much notice. But because it happened at Calder Hall that press naturally gave this story considerable space, and some papers painted a rather lurid picture of what Sir William Cook saw when he hurried hotfoot to the spot. Thus, even the sedatest of the London dailies described "scenes of desolation," and reported that a heat exchanger had been "demolished" by a flying mass of debris. This last report, we have since been assured by the Atomic Energy Authority, is quite untrue. The investigation of the accident, which it is suggested may have been due to a fault in the governor, was taken over last Monday by Mr. P. T. Fletcher, deputy managing director of the Industrial Group, U.K.A.E.A. This investigation may lead to some interesting conclusions, just as have earlier examinations of such accidents to turbo-generators. The interest will be taken by engineers of several kinds, but it will probably be very little, if at all, influenced by the chance association of the turbo-generator with a nuclear plant. The consequences of the mishap for the country's supply of military plutonium may, possibly, be of some concern, particularly because we may suspect that the recent decision to use civil nuclear power stations for making such plutonium was prompted by a shortage: but any other significance for the civil nuclear power programme is nil.

## The Engineer — 100 Years Ago (JULY 2, 1858)

"THE END OF THE SOHO WORKS"

"In a comparatively short space of time only a small vestige of what once constituted the far famed Soho Works, Birmingham—the scene of the triumphs of the great James Watt—will remain to indicate to the visitor the spot on which these extensive premises have stood; and it may not be uninteresting to our readers to learn the circumstances under which the demolition, which is fast progressing, has been induced. It is well known that after remaining for some years untenanted the works were taken by Messrs. Toy and Son, of London, and speedily once more resounded with the din of busy manufacture.

"But in the interim there had sprung up, in and around Soho-park, an abundance of superior and aristocratic looking dwellings, a new church had been erected in the vicinity, and the pool had become a popular resort for recreation and amusement. No sooner was Messrs. Toy's business in full operation than it was discovered that the volumes of smoke, emanating from the works, were productive of an intolerable nuisance, and Mr. Moulton and Messrs. Toy were speedily threatened with legal proceedings. Fortunately, however, litigation was avoided, an amicable arrangement, as we are informed, come to, by which Messrs. Toy have undertaken to transfer their manufactory to Spring Hill. It is understood that the materials will, so far as practicable, be used in the erection of the new works. We have said that only a small vestige of the old Soho will remain. This will consist of the principal elevation of the well-known building, its front and wings. The walls and foundations have been examined and found to be solid and substantial. The internal walls only will therefore be taken down, and the area thus obtained will be converted into four first-rate residences. The mill pool behind will be drained, and afterwards formed into an artificial lake to ornament the rear of these dwellings, whilst the space gained by the removal of the workmen's cottages and by the inclusion of some pieces of vacant land will be laid out and planted."

# Laboratory Methods of Measuring Thrust

By P. N. ROWE*

No. II—(*Concluded from page 967, June 27*)

*The recent development of jet propulsion and rocket motors has re-aroused interest in the thrust or reaction force produced by a gas jet. Some forty to fifty years ago there was similar interest during the development of steam turbines. This report discusses the various methods by which thrust can be measured, sets out their various advantages and surveys apparatus that has been built and used. The survey is concerned only with laboratory apparatus and not with the full scale testing of "hot" motors which has been dealt with by Bierlein and Scheller (1953). The survey does not claim to be in any way complete as recent work in particular has either not been reported or is security classified. The difference in thrust between the worst and the best designed nozzles is rarely more than 20 per cent and usually research is concerned with much smaller differences than this. Hence, the traditional accuracy of ±1 per cent is rarely satisfactory if this refers to the fraction of the total thrust for it is likely to be nearer ±10 per cent of the differences under consideration. Thus, thrust measurements are required with a high degree of precision and most investigators to-day are thinking in terms of an error variation of ±0·1 per cent of the total thrust value.*

*Free Movement with Soft Flexure.*—Stanton (1926) used a nozzle fitted to a free piston in order to discharge to sub-atmospheric pressures (Fig. 15). Air was discharged downwards through a nozzle which was part of a piston sliding in a cylinder which led to a

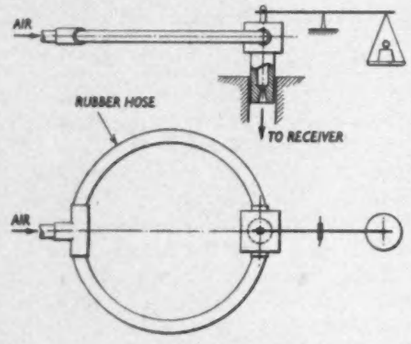


Fig. 15—Stanton (1926)

suction pump. The piston assembly was supported from the arm of a balance and air was supplied through two loops of flexible rubber hose. The differential air pressure over the piston must be added to the recorded thrust. The reservoir pressure was 45 lb per

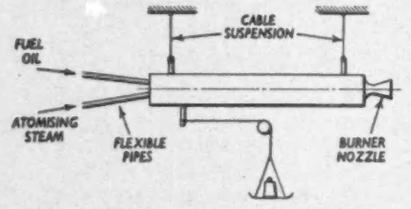


Fig. 16—Collins, Mayer and Newby (1953)

square inch (absolute) and the reservoir pressure varied from 4 lb to 10 lb per square inch (absolute). The nozzles were of approximately ½in diameter throat and thrusts of about 12 lb were recorded. The accuracy is reported as better than ±1·5 per cent.

Collins, Mayer and Newby (1953) measured the thrust of an oil burner with a rig that allowed free movement except for the flexible fuel pipes (Fig. 16). An atomiser and burner nozzle were suspended by wire cables and the flame ejected horizontally. Flexible pipes carried the fuel oil and the atomising steam. The thrust was measured by a weighing pan on a cable running over a pulley. Thrusts of the order of 2 lb were recorded with an accuracy of about ±2 per cent.

McInerney, Mattocks and Newby (1955) have measured the reaction of air and steam jets as a part of a study of entrainment in oil burners. The nozzle discharges horizontally and is supported by a wire frame (Fig. 17). It is supplied by a vertical flexible hose and

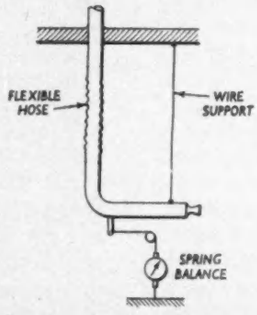


Fig. 17—McInerney, Mattocks and Newby (1955)

the reaction is measured by a spring balance. Steam was supplied at up to 100 lb per square inch and the nozzles varied from $\frac{3}{16}$in to $\frac{7}{16}$in throat diameter. Thrusts of up to 100 lb were registered but no figure is given for the accuracy. Examination of the plotted results suggests that it was no better than ±3 per cent.

Hubble and Sinclair (1956) describe a small thrust rig that allowed free movement except for the coiled copper feed pipe and pressure gauge connection (Fig. 18). The nozzle is attached to one end of a balance beam and discharges downwards, transmitting the thrust to an electric force transducer below the other end of the beam. The nozzle was supplied with hydrogen peroxide "steam" up to reservoir pressures of 650 lb per square inch and the nozzles had throat diameters of the order of 0·1in. The maximum thrust recorded was about 12 lb. The sensitivity of the balance was about ±0·03 lb, but the standard deviation of repeated observations was approximately ±0·2 lb or ±1·5 per cent of the maximum value.

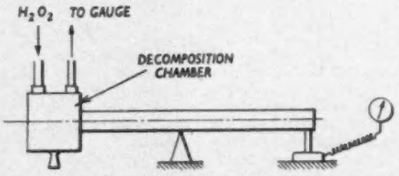


Fig. 18—Hubble and Sinclair (1956)

*Thrust Comparison.*—The apparatus of Kisenko (1940), already described (Fig. 9 *ante*), specifically makes provision for an opposition nozzle so that direct comparisons of thrust can be made. The sensitivity of this apparatus should be high so that accurate comparisons are possible, but no mention is made of results obtained in this way.

Clemmow and Lambourn (1953) describe a pendulum thrust rig that measures the difference in thrust between two opposing

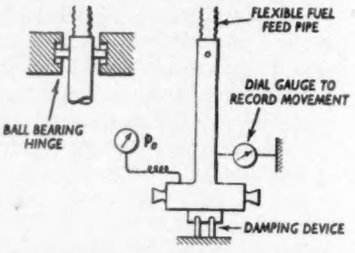


Fig. 19—Clemmow and Lambourn (1953)

nozzles (Fig. 19). A vertical pipe hangs from a ball bearing hinge and may swing as a pendulum. The bottom of this pipe contains a hydrogen peroxide decomposition chamber to discharge horizontally through opposite nozzles. The liquid fuel is fed through a flexible pipe above the hanging pipe. Oscillations are damped by a magnetic device below the pendulum. The thrust difference is recorded by measuring the movement on a micrometer dial gauge. Reservoir pressures are of the order of 300 lb per square inch and the nozzles are of approximately 1in throat diameter. A standard deviation of about ±0·2 per cent of the total thrust is claimed, which is about ±¾ lb. However, this high accuracy is of the order of ±4 per cent of the differences that are observed generally.

Fawn (1956) has designed a similar pendulum type thrust comparison rig (Fig. 20).

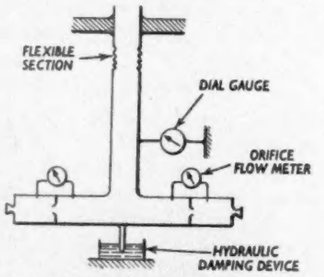


Fig. 20—Fawn (1956)

The hanging supply pipe is not hinged but contains a flexible section. Lateral movement is measured by a dial gauge. The horizontal branches of the feed pipe, which end in the two opposite nozzles, contain metering devices so that unequal flow rates through the two nozzles can be allowed for. A paddle below the pendulum rests in a bath of viscous fluid which serves to damp

*List of Symbols*

$A_e$—Nozzle exit area, square inches.
$A_t$—Nozzle throat area, square inches.
$D_e$—Nozzle exit diameter, inches.
$D_t$—Nozzle throat diameter, inches.
$F$—Thrust, pounds.
$P_r$—Reservoir (stagnation) pressure, pounds per square inch.
$P_e$—Exit pressure, pounds per square inch.
$P_a$—Atmospheric pressure, pounds per square inch.
$W$—Weight, pounds.
$w$—Weight flow rate, pounds per second.
$u_e$—Jet exit velocity, feet per second.
$u_a$—Gas approach velocity, feet per second.

*Principal Scientific Officer, Chemical Engineering Division, Atomic Energy Research Establishment, Harwell.

troublesome oscillations. A flexible tie bar prevents lateral movement across the plane of the pendulum swing. Air is supplied from a continuous source at reservoir pressures in the region of 60 lb per square inch. The nozzles are of 2in diameter throat so that they develop some 300 lb thrust. An accuracy of $\pm 1\frac{1}{2}$ lb is claimed which is $\pm\frac{1}{2}$ per cent of the total thrust, but a much greater fraction of the differences usually examined.

N.O.T.S. (1957) have used a similar vertical "T" arrangement, but stood it above a flexible base support rather than suspended it as a pendulum (Fig. 21). This rig is not

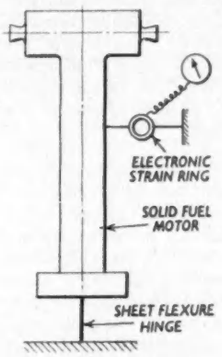


Fig. 21—N.O.T.S. (1957)

strictly within the scope of this survey as it is really a solid fuel motor. A vertical hot propellant gas generator supplies two horizontal opposing nozzles, and the whole is mounted above a sheet of stainless steel set on edge which acts as a flexible hinge. The differential force is recorded as a strain in an electronic strain ring. No figures of the performance and accuracy of this rig are available.

*Momentum Measurement.*—Morley (1916) measured the momentum of an air jet by the impact method (Fig. 22). A 12in diameter plate received the jet, which was discharged

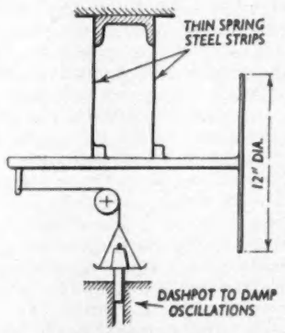


Fig. 22—Morley (1916)

horizontally. The impact plate was suspended by spring steel strips and a weight and pulley arrangement restored the plate to its original position and measured the impact. A dashpot beneath the weight pan damped oscillations. Nozzles of 0·2in throat diameter were used and air was supplied at up to 70 lb per square inch reservoir pressure. Thrusts of up to 5 lb were measured. The accuracy is discussed at some length and claimed to be about $\pm 0{\cdot}07$ lb or $\pm 1{\cdot}5$ per cent of the highest values. It is noteworthy that Morley found thrusts measured by impact and by direct balancing did not agree within the limits of experimental error. There is extensive discussion of this anomaly.

The Steam Nozzle Research Committee (1923–30), after considerable deliberation, chose an impact method of measuring momentum in preference to a direct measure of thrust. They were convinced that a flexible pipe could not be relied upon and that a movable joint would be excessively stiff or leak seriously. They were acutely aware of the anomaly between impact and thrust measurement. The impact device they finally evolved for testing steam nozzles was considered to be free from the usual objections

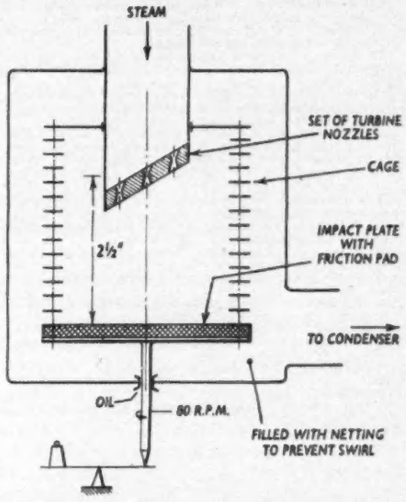


Fig. 23—Steam Nozzle Research Committee (1923)

(Fig. 23). The impact plate was set horizontally and the jet was directed down on to it. The surface of the plate was covered by a mesh or friction pad so that any gas leaving the surface of the plate radially did so with virtually no velocity. In this way the aerodynamic effects are minimised. The plate carried a cylindrical cage rising from its periphery to well above the nozzle. The cage was made from a number of flat metal rings spaced so that gas leaving the region above the impact plate could only do so radially. The impact plate was supported on a vertical rod above a scale pan. The rod passed through a gland in the wall of the surrounding condenser chamber, and the friction in this gland was minimised by pumping a little lubricating oil through it and by rotating the rod slowly. The apparatus was first tested with air and in these tests a hinged joint was used so that the thrust could be measured directly. In this way it was shown that the impact method and direct thrust measurement agreed within the limits of experimental error.

Nozzles of total throat area between 0·5 and 1·5 square inch (equivalent to 0·8in to 1·4in diameter) were used and supplied with steam at up to 50 lb per square inch. Thrusts of up to 50 lb were recorded. The sensitivity of impact measurement was $\pm 0{\cdot}01$ lb, but the

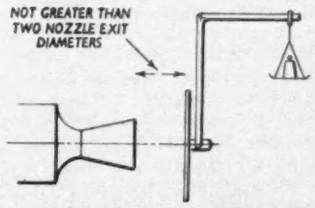


Fig. 24—Kisenko (1940)

standard deviation was about twice this. However, the error in the calculated velocity coefficients was between $\pm\frac{1}{2}$ and $\pm 1$ per cent.

Kisenko (1940) describes a simple impact plate that does not incorporate any of the above refinements (Fig. 24). The nozzle discharges horizontally against an impact plate which is held in position by counterweights acting through a system of levers. Kisenko points out that the momentum term as measured by impact differs from the thrust as directly measured by the pressure term. He makes no mention of the aerodynamic effects on the plate. It is not clear which results were obtained with this apparatus and no accuracy can be deduced.

Palmer (1952) has measured the thrust of rocket motors by firing them downwards on to a plate supported on pressure capsules. It is reported that the thrust is greater than the thrust measured directly, but the difference is attributed to afterburning.

*Velocity Measurement.*—Mellenby and Kerr (1921) estimated the velocity of a steam jet from a $\frac{1}{4}$in diameter nozzle by means of search tubes.

Stanton (1926) attempted to determine velocity by pitot tube measurements in an air jet, but concluded that the local temperature could not be measured with sufficient accuracy.

Warren (1954) has examined the pressure distribution in a free air jet, although not with the specific object of assessing velocity and thrust.

Prandtl (1904) suggested a theory which was used by Altman (1947) to estimate the velocity and hence the thrust of a jet. The theory relates the wavelength of the standing waves in a supersonic jet to the Mach number. The (diminishing) wavelengths are measured either visibly, in the case of luminous jets, or from shadow photographs, and are plotted along the jet axis. The original wavelength at the nozzle exit plane is obtained by extrapolation. The method makes various assumptions about the nature of the flow. It is not capable of high accuracy.

Bundy, Strong and Gregg (1951) have devised a method of estimating the velocity of a high velocity luminous gas jet. It depends upon the Doppler effect on the wavelength of the emitted light. Since jet exhaust velocities are small compared with the speed of light, the accuracy is poor and estimates to $\pm 7$ per cent only are possible.

Bollinger and Edse (1956) are developing a method of introducing a boron tracer into a hot jet and detecting it by its spectral emission. The method is not yet fully developed, but it appears unlikely that it will give the precision necessary for thrust estimation.

## Non-Axial Forces

It is sometimes required to measure non-axial forces as well as a main component. These may be small, as when investigating inadvertent misalignment, or comparatively large as when the jet is deliberately deflected. The methods of thrust measurement already described can generally be adapted to measure perpendicular forces also. This usually means a combination of two thrust measuring devices.

Anderson (1948), Newkirk (1949) and Rogers (1953) have discussed the theoretical requirements for measuring non-axial forces.

The Steam Nozzle Research Committee (1923) and Loring Wirt (1924) both used what has been described as an "anglometer" to detect the jet direction. This is a vane freely hinged at its leading edge so that it takes up the jet direction. This is a comparatively crude device, but once the stream direction and the axial thrust are known, any non-axial forces can be estimated.

Blackaby (1951) discharged an air jet over the surface of a parallel flat plate on to which

a thick oil had been spread. The resulting streak pattern was used to estimate the jet direction. Force measurements were also made by a flexure method.

Fraser and Rowe (1958) and Rowe (1957) have measured the non-axial forces associated with a deflected jet. The apparatus uses two degrees of free movement, a rotary joint and a free piston. Perpendicular forces were measured with an accuracy of about $\pm 2$ per cent of the mean value. This could be improved upon if the range of values was reduced.

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# Nuclear Energy for Electricity Supply Overseas

*Two of the papers discussed at the British Electrical Power Convention at Brighton two weeks ago were concerned with nuclear energy for electricity supplies. Sir Christopher Hinton spoke on the situation in this country and Sir Claude Gibb dealt with prospects abroad. Abstracts from Sir Christopher's paper, with a condensed account of the discussion, were reproduced on page 958 of our issue for June 27; below we present a slightly abridged version of Sir Claude's paper and the discussion it aroused.*

ANY electricity supply authority, whether nationally, municipally or privately owned, undertakes to supply electricity continuously at economic rates, and an implied condition is that it will give service of a high order. The chairman of a large overseas electricity commission once remarked "I can survive criticism that power plant has been installed a year earlier than it was really necessary, but I would be sacked if we had any more power cuts." That is the philosophy ruling in the great majority of supply bodies, and so used have we all become to the instant availability of electricity that we are in danger of overlooking the economic effects of such an approach.

In the more highly developed countries of the world, electricity is a major factor in the high industrial productivity which enables a high standard of living to be maintained. It is only where there is no electricity supply that one realises fully just how much of a luxury is that which we in industrial areas demand as a necessity. Between nations (even in Europe, which might be expected to have comparable consumptions of electricity per head), there are wide variations which appear to be reflected in the gross national product per head and, when considered in conjunction with figures for U.S.A. and Canada, lead to the belief that without a high consumption of electricity per head there can be no high living standards. This appears to be the case even with nations that have some especial natural resource, such as oil, which may provide a high gross national product per head yet have a low electricity *per capita* consumption. The reason for this is that the national income is in the hands of a relatively small number of people and only those few would use electricity on a large scale. There appears to be ample evidence that national prosperity increases with increase of electricity consumption per head, and that this applies throughout the world with but few exceptions which are capable of ready explanation.

A study of world reserves of coal and oil shows them to be quite incapable of meeting alone the fuel demands which would be made if electricity consumption continues to grow as it has during the past fifty years. The requirement for some additional or supplementary fuel is with many nations to-day, and will be with many others within ten or twenty years.

## Size and Cost of Plant and Fuel

Here one must specify what may be accepted as "large," "medium" and "small" when applied to electricity outputs. An output of 10MW may be regarded as large in one country and small in another. Five years ago in Britain, 60MW was large; to-day it is medium, and in five years it will be regarded as small. It is necessary to take arbitrary sizes which, in the short time of a decade, will need adjusting upwards. *Small* reactors are therefore classified as those with a net electrical output not exceeding 20MW. *Medium* reactors are those between 20MW and 100MW, whilst *large* reactors can be taken as those with a net electrical output exceeding 100MW.

Calder Hall, with a net electrical output per reactor of approximately 38MW, is therefore a medium reactor, but the four nuclear stations currently building in Britain, which have been developed from Calder Hall, are large. Considerable reductions in capital cost per kilowatt installed have already been made, and the possibilities of still further reductions can now be seen as the result of further research. Probably the biggest single factor in capital cost reduction is the increase in reactor output. The very large natural-uranium graphite - moderated gas - cooled reactor becomes truly competitive with coal-fired stations in Britain even with coal at its present price. It is relevant to ask for how long will it be possible to persuade men to work in the bowels of the earth digging coal unless they be paid wages that will make coal uncompetitive with other fuels, including uranium.

Modern hydro-electric power stations throughout the world are to-day costing between £100 and £150 per kilowatt of capacity installed. In most countries suitable hydro-electric sites are fairly remote from load centres and long and costly transmission lines are required. Hence hydro stations can be classified as of high capital cost. Hydro fuel costs and station operating and maintenance costs are however extremely small, generally well below one-tenth of a penny. Furthermore, hydro stations are frequently reckoned to have a life of between fifty and eighty years, and thus depreciation and/or sinking fund charges are also low. Thus the high capital cost is spread over such a long period as rarely to amount to a unit charge as high as that of a coal-fired station costing a half or even less per kilowatt installed but arbitrarily given a life of about twenty-five years. A coal-fired station to-day of large capacity—say 600MW to 800MW—would cost between £50 and £55 per kilowatt installed.

A large nuclear station consisting of two reactors with an output of 600MW would cost some £110 per kilowatt installed, exclusive of the first charge of fuel. It would have a fuel cost per kilowatt-hour approximately one-half that of a modern coal-fired station at British coal prices, but British coal is between three and four times as costly as that in many power stations in U.S.A. Hence a modern nuclear station in Britain would have a capital cost about double and a fuel cost also almost double that of the more fortunate large power stations in U.S.A. This would mean total electricity generation costs about double that of, say, the Kingston power station of the Tennessee Valley Authority of U.S.A. Obviously there could be no case for a nuclear power station there until coal costs increased fourfold. And so it will be in many parts of the world: Venezuela with its apparently inexhaustible supplies of natural gas; Victoria in Australia with its two thousand years' reserves of brown coal; there it is impossible to make a case for nuclear power as we know it to-day. But in other countries already the traditional fuels are in short supply or the fuel reserves are limited and must be supplemented.

It is not always realised that in burning coal or oil we are using up capital. It is interesting to speculate upon the future of some of the major oil-producing countries twenty-five, fifty or a hundred years hence. Many of them appear to be paying inadequate attention to the possible need for an alternative economy to that which at present is based upon oil. What will happen to some of the Middle East areas when their oil reserves are used up? Will they revert

to their condition of fifty years ago ? Will their population increase have been so great that their low rainfall and poor quality land make it impossible for them to feed themselves and their drastic drop in oil revenues prevent them from importing food ?

Britain has already faced the serious effect of greatly reduced coal exports, and has not yet found an alternative export with which to produce regularly a favourable balance of trade. World coal and oil reserves are great, but are not inexhaustible, and the projected increases in world energy demands show clearly how necessary it is to develop as quickly as possible alternative ways of providing that additional energy which almost entirely must be in the form of electricity. Electricity produced by the fusion of some of the lighter atoms is a possibility at some unknown time in the future. It is an exciting and promising possibility, and may well be developed in time to meet the long-term needs of the world, but it is to the fission of the heavy atoms that we must look for assistance in the immediate future.

### Electricity Generation

The essentials of any system for electricity generation may be stated as : (1) reliability of the highest possible order, with consequential high availability of supply ; (2) minimum cost per unit of electricity delivered (this covers capital and fuel and maintenance costs per unit) ; (3) minimum nuisance from smoke, dust, effluent, or other factor likely to cause opposition to the siting of the power station for minimum transmission costs. A power station employing steam turbines requires large quantities of condenser cooling water regardless of the fuel used.

The need for reliability is obvious, since if there are doubts regarding plant availability when power is required, then standby plant must be provided at increased capital cost. This is important when considering the choice of reactor for installation in a public electricity supply system. Safety is inherent in reliability, and also plays an important part in deciding on the siting of a nuclear power station. Should there be the slightest possibility of danger during construction or operation there will be opposition to any site near a load or population centre, thus increasing transmission costs.

A nuclear power station employing gas-cooled graphite-moderated reactors complies fully with the essentials for electricity generation. If correctly designed it is inherently safe, and since provision can be made for changing fuel elements whilst on full load it can be given availability of a very high order and at least equal to any coal or oil fired station. The number of fuel elements in a gas-cooled, graphite-moderated reactor of, say, 200MW net electrical output is over 20,000, and despite the utmost care in manufacture and installation, it is to be expected that one or two will either possess at start, or develop at an early stage of operation, some minor defect which will call for their replacement. With fission product detection applied to every channel any such defect is readily located, and with on load fuel charge and discharge equipment the defective fuel elements are quickly and simply changed without shutting down the reactor or even reducing load on the power station. This ability to detect and rectify whilst on load is regarded in Britain as an essential feature of design and would be so regarded by most experienced power plant operators. The application of the on load charge/discharge principle to any other than a gas-cooled reactor introduces formidable engineering problems, an elegant and acceptable solution to which has yet to be found.

### Research and Development

Only Britain of all nations of the world has committed itself to a large nuclear power programme. Britain has had the need for supplementing fuel, but has also had the courage, the ingenuity and the skill to develop it and apply it on a large scale. Calder Hall and its successors have given Britain a commanding lead in the new era of nuclear power, but are we going to be able to maintain that lead ?

Britain's need for a supplementary fuel is so great that research and development on a very large and adequate scale is proceeding both within the Atomic Energy Authority and in industry. Much of the research and testing necessary for that development requires equipment on a scale and of a cost that is quite beyond the ability of private industry to provide for itself at the present stage of world nuclear demand. Industry is already spending huge sums annually on research and engineering design studies, and will find this expenditure crippling unless orders for nuclear equipment are received on a scale and at a price which will enable that expenditure to be recovered.

Metallurgical developments are essential to future progress in nuclear power, and collaboration between the U.K.A.E.A. and industry is particularly close in this field. But the effects of irradiation upon materials are so unpredictable that every new alloy of whatever metal or material used must be tested for long periods in a reactor capable of flux of the order of $10^{14}$ neutrons per square centimetre per second. Such a testing reactor is very expensive.

Assessments made independently within the U.K.A.E.A. and in industry have given a figure of approximately 1000 man-years as the effort necessary to reach the prototype design stage of a new type of reactor after the basic research has been completed and the feasibility study has been made. The effort required to prepare the tender for one of the first 300MW nuclear stations in Britain approached 1000 man-years, while that to design and prepare a tender for a single-reactor, 200MW station exceeded 500 man-years. Research and development in the British nuclear industry at the present time probably is employing some 10,000 scientists and engineers and, when added to the U.K.A.E.A. effort, is an indication of the importance attached to nuclear development.

The scale of effort required to develop a new type of reactor is such that inevitably it has been necessary with our limited resources in manpower and money to avoid spreading those resources over too wide a field. This has led to the major effort being concentrated on large output schemes, such as are required for Britain and would be suitable for highly developed countries overseas. Italy, France, Germany, Holland, Canada, India, Russia, Australia, all have integrated electricity supply systems of a magnitude to justify the installation of reactors exceeding 100MW net electrical output, provided that the electricity costs generated from such nuclear stations do not exceed those of traditional stations.

### The Market for Britain

In many of those countries of Europe which are highly industrialised and able to accept large blocks of electricity into their systems, many of the components constituting a nuclear power station either are already manufactured in that country or could be made with limited adaption of their existing industrial equipment. Extremely detailed information regarding the design and construction of Calder Hall has been given to the world, and much information on the designs of the four British nuclear stations has already been published. Hence the main thing British industry has to sell in highly industrialised countries is experience in design details, in construction and, shortly, in operating experience additional to that already obtained from Calder Hall. But it is just that detailed experience which can and almost certainly would enable savings of many millions of pounds to be made on each nuclear station built.

To the countries which could not accept a reactor of large size, Britain has little to offer which would be both economical and based upon proven designs. Natural-uranium gas-cooled graphite-moderated nuclear stations can be designed for efficient operation at least down to 60MW output. But the capital cost per kilowatt installed almost certainly would be unacceptably high. Although it would be possible to design a natural-uranium gas-cooled graphite-moderated reactor down to below 30MW net electrical output, the project would have little prospect of being acceptable from an electricity cost viewpoint.

The ability of an electricity supply system to accept the output of a large nuclear generating station almost invariably implies a surrounding highly industrialised district. Hence the nucleus of a competent operating staff almost certainly could be obtained from local industry and technical institutions, and these, with limited training, could with safety be entrusted to handle a nuclear power station. This, however, would unlikely be the case where only small or medium outputs could be justified. Furthermore, annual and daily load factors are likely to be lower in smaller electricity systems and will have considerable influence upon reactor selection. Also, in general, the larger the system, the more probably will that system be able to finance a large capital project either from its own resources or by raising money on more favourable terms and at lower interest rates than could a smaller undertaking. High interest rates and low load factor both call for minimum possible capital costs with fuel costs being of lesser importance. Hence, if by the use of enriched and therefore expensive fuel, a nuclear station of lower capital cost per kilowatt installed can be constructed, such a station may be more economic than a natural-uranium-fuelled one.

### Effect of National Policy

Uranium enriched in the isotope $U^{235}$ is generally produced in a diffusion plant and its enrichment requires large quantities of electricity for the process. A diffusion plant on even a moderate scale would demand about 1,000,000kW. The cost of the enriched fuel produced would be a function of electricity and therefore fuel costs. Fuel costs, whether coal, natural gas or oil, are so much lower in U.S.A. and U.S.S.R. than in Britain that enriched fuel produced in Britain would be more costly than that from the other two major nuclear-experienced countries.

The original and prime purpose for installing diffusion plants was the production of bomb material. Once adequate stocks of enriched uranium for military purposes have been manufactured, and peace, however uneasy, continues, a nation may decide to supply surplus enriched fuel for industrial purposes.

Plutonium is less attractive chemically and nuclearwise than $U^{235}$ but may well have

economic advantages if produced as a by-product of electricity generation in thermal reactors.

National policy as to the price at which fuel would be supplied could be all important in the development of nuclear power, particularly in the less developed countries. One nation may decide that since the huge capital cost of the diffusion plant or plants has been written off against military budgets, then the price at which the enriched fuel would be supplied need only cover annual operating costs or even less if it be argued that continuation of production in the diffusion plant is a military necessity.

Sir Christopher Hinton has described enriched uranium as "potted electricity" and this is very apt. According to accounting, there could be very wide variations in the estimates of production costs and, according to national policy, even wider variations in the quoted selling price for enriched fuel. It is impossible to forecast what prices will be charged for such fuel and, probably even more important to potential purchasers, how much reliance could be placed upon continuity of supplies in the event of a worsening of the international situation. Would the threat of war, let alone actual war, suddenly deprive a nation of its fuel supplies which could only be obtained from, say, one nation ? That question must be uppermost in the minds of governments considering the installation of nuclear plants, and be ever present with the designers of such plants.

Uranium ore is found in a number of widely dispersed parts of the earth's surface and the cost of the plant required to refine the ore and produce natural uranium metal, although high, is only a fraction of that of a diffusion plant, and it also requires relatively little electrical power compared with that necessary for the production of enriched uranium. Hence, strategically, there are strong arguments in favour of developing reactors which can employ natural uranium as the fuel. For small and medium power outputs, however, natural-uranium-fuelled reactors, except in special cases, appear to be uneconomic because of their high capital costs.

A third possible fissile material is the isotope $U^{233}$ which can be bred in thorium used as an absorber in a thermal reactor, thus assisting flattening, or used as a blanket surrounding the core. $U^{233}$ is in many ways an admirable fuel, having few of the many disadvantages of plutonium. In time, it may be found that plutonium will be used in conjunction with thorium for fuel elements inserted in selected areas of an otherwise natural-uranium-fuelled reactor. Thorium is probably only about one-ninth the price of uranium and is found in many places on the Earth and thus again, like uranium, eventually will be available in the free markets of the world.

If it were possible to have firm prices quoted for enriched fuels, and their availability to be assured without any form of reservation, then the reactor designer's problems would be greatly simplified.

### Reactor Materials

There are four possible moderators and four systems of cooling which may be used with thermal reactors. Thus there are sixteen possible types of thermal reactors. The selection from these sixteen is not so difficult for the engineer as for the nuclear physicist, since the engineer must consider availability of materials, the existence of suitable manufacturing techniques and, by no means least, cost.

*Moderators.*—There is first the light hydrogen atom in ordinary (although pure and demineralised) water, or an organic liquid such as diphenyl or terphenyl. Light water absorbs too many neutrons for the fuel to be natural uranium, and therefore some degree of enrichment becomes necessary. Most organic liquids polymerise or break down under irradiation, but those based on benzene rings offer promise. An alternative moderator is the heavy hydrogen atom in heavy water. This is most attractive since its neutron capture is extremely small and natural uranium could be used with it. Carbon is a third possibility, and the obvious way of using it is in the form of high-purity, high-density graphite. In this form it has more than adequate strength at any temperature possible in a reactor, and it can be produced in almost any shape and in a wide range of sizes. Finally comes the beryllium atom either in the metal or the oxide beryllia. The latter is cheaper than beryllium metal but either form is expensive and difficult to work, as well as having serious toxic effects.

Graphite is the moderator used in Calder Hall and in the four large nuclear stations currently building in Britain. Light water is favoured in U.S.A. because enriched fuels are available, and has been used in the U.S. Navy submarines of which the "Nautilus" has been operating longest, and at the Shippingport station of Duquesne Light and Power Company. Canada has pinned its faith in heavy water and, provided heavy water is available at an economic price, this is a most desirable moderator.

Beryllium is the subject of intensive investigation in both U.S.A. and Britain at present but availability and cost are likely to restrict its usage for the time being to fuel cladding as a better material both nuclear- and temperature-wise than aluminium or magnesium.

*Coolants.*—The four coolants which are possible are gas, heavy water, light water, or liquid metal. A liquid containing light hydrogen atoms (a hydrocarbon) which is stable under intense irradiation is another possibility upon which much research is being carried out. A coolant, like a moderator, must not absorb so many neutrons as to call for enrichment of the fuel. The ideal coolant would have a low neutron capture ; a high heat transfer rate ; be non-corrosive and compatible with the fuel and/or its cladding material ; be readily circulated, i.e. use only a small proportion of the total power produced ; not suffer structural breakdown under irradiation ; be readily obtainable and reasonably cheap. Finally, it must enable good steam conditions to be obtained for the main generating turbines.

No coolant fulfils all or, in fact, many of these desiderata. Heavy water has the lowest neutron capture and a reasonably good heat transfer, but it is very costly and could only provide poor steam conditions for the main turbines. Corrosion problems, although not severe, are nevertheless sufficiently troublesome as to throw doubt on the essential long-term reliability of the system. Light water has the advantages of heat transfer, low pumping powers, low cost, and availability, but has a higher neutron capture and some corrosion problems. Like heavy water, it can only provide saturated steam for the turbines. Several designers advocate interposing an oil-fired separate superheater between reactor heat exchanger and turbines to overcome the troubles associated with wet steam. Quite apart from the undesirability of utilising two different types of fuel, a study of the economics of a separately fired superheater shows that in almost every case there is no reduction in total electricity generating costs. Since, with other coolants, it is possible to obtain reasonable steam conditions including adequate superheating without adding the complication of the oil or gas-fired superheater, there appears to be little ground for a binary fuel cycle.

Liquid sodium has outstandingly the highest heat transfer and lowest pumping costs. It is readily available and not too expensive. It could be used at quite low pressures and at first sight would appear greatly to simplify the engineering problems of the reactor. Sodium, however, demands a leak tightness which, when studied in detail, becomes formidable and quite frightening when considered for use in other than the most skilled operator's charge. The danger of a severe fire, should any sodium come into contact with water or steam, is great, and it would appear that a sodium-cooled reactor could not at present comply with the reliability and safety criteria laid down for normal power stations.

Finally there is gas as the coolant, as adopted at Calder Hall and the four stations currently building in Britain. Of the many gases available, carbon dioxide is used because of availability, compatibility, good heat transfer and cost. Helium if available at reasonable cost would have some advantages. Hydrogen is not suitable for present designs.

Any liquid obviously would have many times higher heat transfer than any gas. If, as the results of research, a heat transfer per foot of fuel element length in any way comparable with a liquid could be obtained with a gas, then one of the objections to gas cooling would be removed. If heavy water is used as the coolant, the capital invested in the cooling circuit external to the reactor is very high and heavy water external to the reactor has no advantage over light water. The cost of heavy water being high, the cooling circuit "plumbing" would require a leak tightness so good as to add to engineering costs by more expensive techniques and design. The great advantage of heavy water is as a moderator. To obtain even quite low saturated steam conditions for the main turbines, either heavy or light water cooling systems must operate at very high pressures to prevent boiling of the coolant. Even if boiling is allowed the coolant pressures are still high and introduce severe engineering problems.

But it is when considering firm power from a reactor that the liquid-cooled reactors show up worst. The heat transfer per foot length of fuel element, other things remaining constant, increases with increasing pressure whether liquid or gas, but whereas the improvement is small with a liquid, it is very considerable with a gas. Hence reasonable steam conditions demand high coolant pressures for a light- or heavy-water cooled system (but not for sodium cooling) while reasonable heat transfer requires the highest pressure obtainable (within other design factors) for gas cooling. If water cooling is at 200 lb per square inch pressure, then boiling would occur at a temperature of 388 deg. Fah. and this would be the maximum available pressure and temperature for the turbines, even assuming 100 per cent efficiency in the steam raising heat exchangers. With gas cooling at 200 lb per square inch, however, there is no limitation to the temperature possible other than that imposed by the fuel temperature. If the maximum temperature of the fuel could be lifted above the present limit of something just over 600 deg. Cent. for natural uranium, as, for example, by using uranium oxide or uranium carbide, then quite high and efficient steam cycles could be adopted. This would involve using a fuel cladding material superior to aluminium or magnesium alloy and this

might well be beryllium. Even at a gas coolant pressure of only 155 lb per square inch, steam at a pressure of 730 lb per square inch and at a temperature of 700 deg. Fah. is readily obtained.

Light- and heavy-water coolant pressures must be at least 1000 lb per square inch and preferably twice that for reasonable steam conditions. The engineering problems associated with on-load fuel charging and discharging when using liquids, and especially an expensive one such as heavy water, are obvious and formidable. These problems are eased considerably if a gas is used as coolant, and a minute leak of gas during charge/discharge is acceptable from both hazard and cost viewpoints.

*Fuels.*—Detailed study reveals that improved heat transfer from fuel to gas, and the ability to operate the fuel at high temperatures, is a most profitable line of development with the promise of lower capital costs and simplified engineering. The latter is an important factor in the design of nuclear stations for overseas. Uranium oxide or uranium carbide would allow higher fuel operating temperatures. Uranium oxide has a low conductivity, but this may not be too serious and the work already done on uranium oxide at Chalk River, Canada, is most promising. Much more work on uranium carbide is necessary before a decision on its use can be made.

*The Choice for Future Reactors.*—From the steam-cycle and engineering viewpoints, the gas-cooled reactor has so many advantages as to be that most likely to offer improvements in reduced capital and total generating costs. Whether the moderator should be graphite or heavy water, primarily is a question of economics in each country.

For small and medium power outputs, a gas-cooled heavy-water-moderated slightly-enriched-uranium-fuelled reactor offers greatest promise of early development. It is unlikely that there will be general agreement on this view, but if it be accepted that on-load fuel changing is essential, then the gas-cooled reactor must take first place.

Higher fuel temperatures ; higher burn-up rates ; longer periods of irradiation ; greater heat transfer rates from fuel to coolant ; techniques for the production and fabrication of new metals and alloys with better qualities for nuclear application, these are the directions in which research and development are proceeding to improve large-output reactors, and upon their solution will depend the speed with which efficient and economic medium and small-output reactors are produced. On the engineering side, greater experience in design, fabrication and construction will bring improvements and cost reductions in large reactors which will be of application to smaller ones.

### Prestige

The case for a major programme of nuclear power stations was for Britain essentially one of urgent need. With some other nations the production of electricity from nuclear fuel could only be justified on the basis of national prestige or else as a by-product of a military programme. The driving force in Britain being need, it has inevitably led to a somewhat different approach to that which might have been taken had it been a case of prestige or normal industrial development in a new field of engineering. In the latter case, more time could have been taken in study of more alternative types of reactor before becoming committed to a programme of construction costing hundreds of millions of pounds.

It is difficult to conceive that Russia, for instance, with its huge hydro-electric resources, with its vast coalfields, and with all human rights subordinated to the needs or demands of the State, could justify on technical or economic grounds the construction of nuclear power stations on the scale of Britain. Yet international politics, as they are played to-day, make it unbelievable that Russia would, or could, allow Britain to gain too much world prestige and leadership in the peaceful nuclear field, or, even more so, permit the United States of America to remain unchallenged in this field. Hence, just as without any heralding fanfare of trumpets, the world suddenly realised that a "Sputnik" was encircling the earth, so we should expect shortly to hear of Russian achievements in the generation of power by nuclear methods. One would expect their programme to be based upon the use of an enriched fuel, thus to keep diffusion plants in continuous operation and ready for military production at short notice. In this event it may well become Russian policy to provide enriched fuel on loan, or at absurdly low prices, for reactors of Russian manufacture, not only to satellite countries but to less developed nations not yet tied to or allied with Russia, but who automatically would become so by the acceptance of Russian fuel and nuclear techniques as the basis for their power programme.

### Training Operators

Although a nation may not have either the technical or economic need to develop or install nuclear power plants, it may decide that national prestige demands that it be able to point to at least one such plant as proof that it also is in the vanguard of progress. Such a policy may well, in the long term, be found to have been wise in that the training of staff and the gaining of experience at a time when there is no pressing need, builds up staff against the day when nuclear power becomes necessary. Without a feeling of urgency, however, it is difficult or even impossible to maintain the enthusiasm essential to efficiency in a scientific and engineering staff.

Nuclear power stations demand a standard of technical competence in the operating staff far above that needed in an orthodox oil, gas or coal-fired station. The need for special staff training should neither be overlooked nor under-rated. Only a nation which is actually operating nuclear stations can provide the training and experience so essential to satisfactory or indeed safe performance. Britain is in that position, and able to provide that essential training.

### Insurance

The British Insurance Association Atomic Energy Committee has led the way in covering such risks as are attendant upon the construction and operation of nuclear power stations, and has already gone a long way towards establishing insurance on an international footing. Little difficulty should therefore arise in effecting adequate cover.

At a recent conference held in this country under the sponsorship of the Committee, members from fifteen European countries agreed that in providing cover for Continental nuclear stations insurance would be effected through a national pool in the country concerned, but the cover would be spread internationally. A single policy taken out by the owner or operator would, it was proposed, cover radiation hazards for all third parties including the contractors.

### Discussion

Mr. F. M. Greenless (U.K.A.E.A.) said that there were as many as 900 possible types of reactor, but a cursory examination reduced that number to about sixteen, several of which seemed to be of almost equal merit. Once a particular type had been chosen and developed, at tremendous expenditure in money and engineering effort, there were powerful reasons for adhering to it and developing it to the fullest possible extent. It was fortunate, therefore, that Britain had chosen a type of reactor which had very great possibilities, and could offer it to other countries. It could be built in its present form by quite a modest extension of conventional engineering techniques, and it had good possibilities in regard to the reduction of initial capital cost. It used natural uranium, which was readily obtainable by most countries, so that any country adopting this type of reactor could look forward to becoming self-supporting in fuel supplies. The reactor and its fuel were offered against the background of a very large domestic programme in advance of the export programme, with all the economic and operational advantages which this conferred. The best choice for a nation entering the nuclear power field was to build, so far as possible out of its own resources, a reactor of proven type, in partnership with an organisation which had done it before. That was what the United Kingdom was offering.

He believed that the fast reactor would eventually find its place in the power programme, although perhaps not quite so soon as had been suggested in some quarters. Partly because of that, and partly because he thought that the problems of using plutonium would be overcome, he believed that the price of plutonium would remain relatively stable. That was a most important point for overseas countries, since generating costs were significantly influenced by the value of the plutonium generated in the reactor. The re-purchase price offered by the A.E.A. was based on these considerations alone, and not linked in any way with military use ; it was therefore not subject to arbitrary fluctuations. Operating experience at Calder Hall had enabled the A.E.A. to begin work on codes of practice to ensure that the overriding safety criteria were understood and applied in both design and operation, and that would have a bearing on the type of insurance eventually given.

Mr. G. F. Kennedy (Association of Consulting Engineers) said that unless in any country the cost of delivering energy from a hydro-electric project was prohibitively high, he would regard it as always in the interests of that country to develop a natural resource, using no fuel, rather than burn up a wasting asset, even if it allowed energy to be produced more cheaply. Other natural assets, such as facilities for constructing hydraulic or pumped-storage plant, could become much more attractive commercially if combined with a producer of cheap energy such as a nuclear plant. For a given demand this would make it possible to increase the load factor under which the nuclear plant operated, and thus increase the capacity of the nuclear plant which would be justified at any given cost per kilowatt. So far as the cost of nuclear plant was concerned, he expected that international competition would result in a nuclear power station with an output of 600MW or more being provided within the next few years at a cost of less than £100 per kilowatt installed.

The financial position of overseas countries might make it necessary for them to use a reactor which could be supplied at a lower capital cost, and this would no doubt mean the development at a reasonable price of slightly enriched fuel. It was stated in the

paper that the U.S.A. had a great advantage over this country owing to the low cost of the electricity for the diffusion plants required to manufacture such fuel. This country should therefore consider establishing diffusion plants close to overseas hydro-electric projects, which would produce power at a fraction of the cost at which it was available in this country. There were many projects, both inside and outside the colonies, which were only waiting for a load such as a diffusion plant could give to justify their development. If that were done this country should be at no disadvantage compared with its competitors in producing enriched fuel at a competitive price.

Mr. E. B. Banks (BEAMA) commenting on Sir Claude's suggestion that in some countries a nuclear power station might be built purely for reasons of national prestige, though unjustified on economic grounds, expressed the opinion that once the glamour and novelty had worn off hard-headed economic considerations would become the governing factor. One factor which might affect the issue, however, was the availability of foreign currency, and in some countries a nuclear power station might be built because of the lack of foreign currency for importing coal or oil.

The cost per unit would be very much affected by interest and amortisation rates, which varied widely from one country to another. Interest rates varied between 4 and 10 per cent, and amortisation periods ranging from fifteen to thirty years had been suggested. This led to correspondingly wide variations in the calculated cost of generation, which was likely to be a deciding factor in the use of nuclear energy.

He felt that the problem of safety had been over-emphasised and was leading to unnecessary anxiety in the minds of the general public. Some dozens of atomic power stations would be built in this country in the next thirty years, and it would not be possible to locate them all away from large centres of population. When it was seen that this country was locating nuclear stations near the load centres, overseas countries would probably do the same. He wondered, however, what would happen in the end to obsolete reactors, because he understood that they would be inaccessible for dismantling for many years after they had ceased to operate.

He believed that it was a mistake to assume that a great new field of export business had been opened up to this country in nuclear plant which would revolutionise her balance of trade. No doubt valuable export business would result, but for some time to come the contracts were likely to be few and far between, and by the time that they became more numerous this country would be faced by intensified international competition. He was confident, however, that British industry was destined to play a very important part in the development of nuclear power overseas, provided it could maintain the clear technical lead which it now enjoyed.

Mr. S. A. Ghalib (BEAMA) said that it had often been emphasised that the capital cost of nuclear stations was the great stumbling block, and in his opinion low capital cost was essential even at the expense of a marginal increase in the cost of units sent out. There were many areas in the world where conventional fuel costs were high and where it would be economic to generate electricity by nuclear means, but it was impossible for the countries concerned to raise the large capital sums involved. With gas-cooled reactors the obvious way to reduce capital cost was to use higher temperatures, but Sir Christopher Hinton had said that it would then be essential to use some enriched fuel in graphite-moderated reactors. With heavy-water-moderated reactors, however, it would still be possible to use natural uranium only. It followed, therefore, that a combination of heavy-water-moderated and gas-cooled reactors held great promise.

The less industrialised countries had not the same incentive as the others to use natural uranium, and were far more interested in low capital cost. It was difficult to see how the pressurised-water reactor could be significantly improved. The boiling water reactor gave steam for use directly in the turbine. The steam was, of course, slightly radioactive, but if it could be demonstrated that, even after a serious failure of a tube element, the turbine could be satisfactorily cleaned and decontaminated, it might be difficult to compete overseas with that type of reactor on capital cost.

Sir Claude Gibb, in reply, assured Mr. Banks that there was no difficulty in decontaminating an abandoned reactor, as had been shown by the experience at Chalk River, where after serious contamination of all the buildings it had been possible to decontaminate and rebuild in eight months.

# Large Electricity Supply Systems

No. IV—(*Continued from page 962, June 27*)

*The seventeenth full session of the International Conference on large electricity supply systems which was held in Paris from June 4 to 14 was attended by delegates from forty countries. The subjects under discussion were: transformers, tele-transmissions, generators, circuit breakers, capacitors, high-voltage cables, system stability and control of load and frequency, insulating oils and materials, insulation co-ordination, reactive and distorting phenomena, protection and relays, voltages over 220kV, lightning and surges, telephone and radio interference. A résumé of some of the papers on cables and of some of the contributions to the discussion is given here.*

TWELVE papers were discussed at the C.I.G.R.E. session on high-voltage cables. To simplify the discussion the papers were classified by the special reporter, Dr. L. G. Brazier, into four groups dealing, respectively, with high-voltage submarine cables, d.c. cables, plastics-insulated cables and special studies of high-voltage a.c. cables.

## Flat Cable

In paper No. 201 Möllerhöj, Sutton and Morgan described the two-core flat oil-filled cable for submarine service, carrying direct current, and they gave details of cable manufacture, testing and of installations completed.

Since 1941 nearly 300km of three-core flat pressure cable have been installed, including about 38km under water, for voltages of 33kV to 132kV. With the basis of this experience the authors described a design of two-core flat cable, in which two copper or aluminium screened conductors, with oil-impregnated paper insulation and core screening of semi-conducting paper tapes interleaved with thin copper foil, are laid side-by-side and enclosed in a lead sheath.

The sheath is reinforced by non-ferrous metal tapes applied circumferentially and by two corrugated metal strips being bound on to the flat faces by means of one or more copper wires. Jute roving and a cotton tape are applied to give a good finish to the cable, which is then protected with an extruded p.v.c. sheath. As an alternative a "Neoprene" jacket could also be applied directly over the membrane reinforcement, made from "Neoprene" tape lapping with subsequent continuous vulcanisation. Further jute roving and fabric tapes are applied as a bedding for the armour.

Compared with the established design for the three-core cable, the two-core design is stated to have better protection against corrosion and additional core screening of low conductivity to improve the thermal rating and ensure a radial field under all current loadings. In a modified version of this two-core cable manila ropes are applied over the jute roving before application of the armouring wires and the result is a circular cable containing two cores laid side by side. After giving details of rigid and flexible joints, high-voltage d.c. tests, load cycle and impulse tests and mechanical tests carried out on four specimen twin-core cables, the authors offered a suggestion for the design of a high-voltage d.c. cable between England and France, based on the modified design mentioned above, in which the overall cable section would be circular. Details of the cable are tabulated below:

TABLE I—*Technical Details of* 160MW *Cross Channel Cable*

| | |
|---|---|
| Voltage between conductor and earth | 100kV |
| Number of cores | 2 |
| Power transmitted | 160MW |
| Sectional area of conductors | 325 square millimetres |
| Conductor screening | 5 × 0·0127cm semi-conducting paper tapes |
| Maximum dielectric stress | 225kV per centimetre |
| Minimum insulation thickness | 5·34mm |
| Thickness of sheath | 2·5mm |
| Dimensions for reinforced sheath | 4·18 × 7·85cm |
| Diameter of armour wires | 5·9mm |
| Number of armour wires | 52 |
| Overall diameter | 11·5cm |
| Weight per metre, completed cable | 30·8kg |

Finally the authors attempted to compare the costs of a number of alternative schemes for a 50km submarine crossing working at 200kV, d.c. ±100kV to earth with circuit capacities of 120MW, 160MW and 200MW. The costs include the laying of the cable, but neglect the cost of any land cable required. The designs compared are: (*a*) flat pressure cable, design stress of 225kV per centimetre; (*b*) two single-core solid type cables assumed thermally independent, design stress of 230kV per centimetre; (*c*) twin polythene cable, minimum dielectric thickness of 9mm; (*d*) compression cable concentric 200kV/5kV design, design stress=250kV per centimetre. The cost of the flat pressure cable for 160MW is taken as unity, and the results are given in Table II:

TABLE II—*Cost Comparison for* ±100kV *Cable Systems*

| Design | 120MW | 160MW | 200MW |
|---|---|---|---|
| (*a*) Flat pressure cable | 0·85 | 1·0 | 1·20 |
| (*b*) Single-core solid | 1·08 | 1·24 | 1·37 |
| (*c*) Twin polythene | 0·88 | 1·02 | 1·18 |
| (*d*) Concentric compression | 1·04 | 1·20 | 1·45 |

## Buried Submarine Cables

The development of submarine power cables in Japan was described in paper No. 205 by K. Ikeda. An island country, Japan

has made considerable use of submarine power cables, beginning in 1912 when the first rubber-insulated cable was laid, to be followed, in 1917, by another r.i. cable across a 3·5km strait to supply power to coal mines. In 1921 a belted, paper-insulated 10kV cable, 21km long, was laid to supply a copper refinery. This cable and a rubber-insulated 20kV cable laid in 1923 are still in service. The preference for rubber in most of these earlier installations is attributed by the authors to the greater ease of handling, despite the greater outside diameter and the inferior electrical characteristics compared with the paper-insulated cable. About 1950 Japan began to use polythene and butyl rubber for insulation, and a recent example mentioned by the author is that of a 20kV cable, 2800m long, insulated with butyl rubber and laid between Innoshima and Mukaijima in 1956.

An interesting account is given in the paper of a method of providing mechanical protection by burying the cable below the sea bed. The machine which was specially designed for this operation consists of a plough mounted on a rectangular box framework fitted with a sled at each corner to allow the machine to be hauled along the sea bed. There are rollers in the middle of the front and rear frames to guide the cable. An adjustable plough is mounted vertically below the rear set of guide rollers. As the machine is winched forward by the cable-laying ship the plough digs a V-shaped trench into which the cable is laid after passing through the guide rollers.

This machine was developed in 1951 after repeated damage had been experienced on a 10kV cable laid in 1942 between Shikoku and Shisakashima ; the damage had been attributed to certain kinds of deep-sea fishing gear. To avoid further damage it was decided to use the plough machine to bury the cable. Accordingly, about half of the route length of 21km was buried at a depth of about 0·3m and no trouble has been experienced since then.

More recently a water-jet machine has been developed for burying submarine cables. It consists essentially of an assembly for delivering water from the ship to a series of inclined nozzles to scour a trench in the sea bed, and for guiding the cable into this trench.

Experiments on electrical corrosion of armouring are also referred to in the paper, as a result of which it is deduced that in the majority of cable installations the main factor in causing corrosive wear are the potential differences set up by the interaction of tidal movements with the earth's magnetic field. In one experiment a composite cable was built up with a central sheathed core surrounded by a number of outer cores which were finished off in various ways, part of the armour being bare and part protected either by p.v.c. or polyethylene or corrosion-proof tape. This 10kV cable had a total length of 21km ; after it had been laid severe corrosion was experienced in certain sections, except where the wires were covered by p.v.c. or polyethylene.

### Cable Project Between Yugoslavia and Italy

An interesting project study for exporting power from Yugoslavia to Italy by means of a submarine cable was outlined in paper No. 110 by Visentini, Asta and Trimani. It is estimated that the amount of electrical energy which could be absorbed in northern Italy from Yugoslavia, if available, would be $1440 \times 10^9$kWh by 1966, with a maximum demand of 480MW. Similarly, in southern Italy demands of the order of 400MW in the five winter months and 320MW in the remainder of the year could be anticipated by 1966. Surplus power could be transmitted from Yugoslavia to Italy (Verona, Trevise, Rovigo, Terni, Naples and Bari) by overhead transmission lines over distances of about 1200km requiring a.c. transmission voltages of 220kV for the northern load centres and 380kV for those in the south.

An alternative scheme studied in the paper envisages the transmission of power from Ragusa on the Dalmatian coast to southern Italy by a submarine d.c. cable following the route Curzola, Cazza, Pelagosa. The basis for this project study is the transmission of 750MW with direct current of 1250A at a voltage of $\pm$300kV. Transmission over the submarine cable would be by direct current and mercury arc converter substations would be installed at each end of the cable. With four-anode converters connected in parallel a voltage of $\pm$250kV or 500kV between conductors would be possible. An alternative arrangement is based on the Graetz circuit with six high-voltage converters forming a three-phase group with two units back-to-back in each phase (and a seventh unit in reserve). Four such groups could be connected in series between positive and negative, with the mid-point earthed, at each terminal substation.

The submarine cable for such a scheme would have a conductor of 300 square millimetres equivalent copper cross section. The insulation, in the case of impregnated paper, would be about 11·5mm thick and would be surrounded by a lead sheath, wire armouring and a protective cover, giving an overall diameter of 85mm.

### Vancouver Island Submarine Power Cable

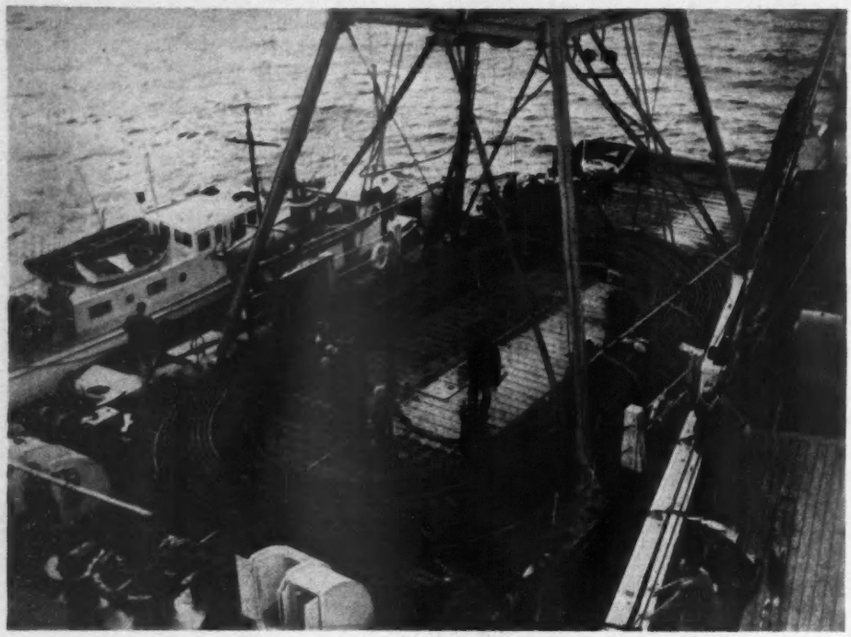
In paper No. 216, Ingledow, Hollingsworth and Williams described the 138kV submarine cable which transmits 120MW from the Canadian mainland to Vancouver Island.

It will be recalled that this gas-filled cable* was specially manufactured in unjointed lengths up to 25 miles long. The problem of laying this unjointed cable had a close effect on the design. From consideration of the individual components of the cable, it was clear that the twisting behaviour would be controlled largely by the metal tape reinforcement and the armour. In a tentative design the reinforcement was in the form of three layers of bronze tapes, each 0·009in thick, applied in succession in opposing directions. The armour wires were laid, as usual, at a pitch eight times the pitch circle diameter. After sea trials had been carried out, laying a specimen length of this cable in 100 fathoms of water, the cable was recovered and tested electrically. It was then found that the cable had suffered mechanical damage consistent with the straightening, under tension, of a loop of the cable. This trial emphasised the importance of the mechanical characteristics of a cable. Reassessment of these properties resulted in the evolution of an improved design in which the armoured tapes were all applied with a right-hand lay and the armour wires were applied at a pitch of twelve times the pitch circle diameter and with a left-hand lay. This cable twisted much less than its predecessor and a series of tests established the amount of bending it could sustain without damage, both with and without tension, the maximum twist it could tolerate in both directions, the maximum permissible direct tension, compression, and so on. Another sea trial was arranged, but this time the test cable had length markers at close spacing and carried a continuous longitudinal stripe. A system of observation was designed whereby the behaviour of every yard of cable was recorded at all stages (except when actually under the water) from the time it left the factory until it arrived back. Subsequent analysis of all the data confirmed that the design was correct, the theory adequate and the handling conditions satisfactory. The way was now clear for planning the laying control procedure for the actual project.

In describing the system of laying control developed for this cable, the authors explained that submarine telecommunication cables are laid slack, that is to say, the length of cable between two points on the sea bottom is greater than the straight-line distance between the points. In fact, laying is largely controlled by continuous observation of the "per-

* *Proc. I.E.E.*, Paper No. 53545, April, 1957

**Laying of 138kV submarine cable between mainland and Vancouver Island. A scow approaching the landing site at Galiano Island, with the cable ship "Ocean Layer" in the background**



138kV cable being loaded on to the deck of a scow from the cable ship, in preparation for landing on Tsawwassen Beach, Vancouver

centage slack " and by adjusting it to the desired level by paying out the cable faster or slower as required. This practice necessitates the cable being laid on the bottom with zero residual tension. This condition could not be tolerated with the 138kV cable or, with such a heavy cable, there would be a serious risk of severe bending on reaching the sea bed and, in the event of sudden changes in speed or direction, a risk of loops being thrown, both of which eventualities might cause damage. It was decided, therefore, that the objective would be to lay the cable on the sea bottom with a small, but constant, residual tension as, under this condition, the cable would still be under control, even though far out of reach, and no damage could arise.

From the work already described, the tension needed at the ship's bowsheave to produce any required bottom tension could be calculated for any depth, any rate of change of depth and for any speed of laying. Also, the length of cable suspended between the ship and the bottom and the position of the touch-down point were accurately predictable under all conditions. Therefore, the simplest of all possible schemes was proposed—that is to say, that the tension variations should be programmed from the depth of water measured by the ship's echo-sounder, the position of which would always be in advance of the point where the cable met the sea bottom.

The laying control was in the hands of two men. One, the captain, who maintained accurate course and speed, making due allowance for currents and wind ; the other, an engineer, who read the echo-sounder and, as called for by the schedule, telephoned instructions to the driver of the cable engine who maintained the required tension. This simple arrangement was inadequate only at one point where, for a distance of about 200 yards landward of the Galiano ridge, the ship was sailing in water of constant depth while the cable touchdown point was still moving down the ridge and, hence, tension changes were needed. Over this narrow region, tension was controlled by reference to the length of cable being paid out, suitable arrangements being made so that the changeover in procedure and back again could be made smoothly and without effort.

For laying the shore ends of cable, no accurate arrangements were necessary because the risks were much less in shallow water and at low laying speeds. Here, laying was controlled by observation of the angle of entry of the cable to the water, the relationship between this and tension being known.

To verify the control procedure during the actual laying operation all the cables were provided with a longitudinal stripe, interwoven with the outer jute serving so that twist could be watched and observers were stationed at all critical points, on shore, on the landing craft and on the ship, so that the whole of the cable was under observation all the time it was being handled. Also, detailed records were kept of position and speed, length of cable, actual tension, angle of entry of the cable to the water, water depth, &c. These data were subsequently cross checked against each other and it was confirmed that the desired conditions had all been met. In the Strait of Georgia, for example, the bottom tension varied between 8 cwt and 12 cwt over the majority of the crossing, but, over about 50 yards only, at the bottom of the Galiano ridge, fell just to zero, but no slack was laid. In Trincomali Channel, the variation was from 10 cwt to 16 cwt, except at two isolated points, where it fell to 5 cwt or rose to 23 cwt.

The measurements of the lengths of cable used were compared with the actual courses, allowing for the measured contour, and with the values originally allowed for the planned courses. Very good agreement was obtained.

### High-Voltage D.C. Cables

A detailed report of service experience with ±200kV d.c. cables and experimental work on ±400kV d.c. cables (both solid- and oil-filled designs) is contained in paper No. 206 by Gorodetzki (U.S.S.R.). Valuable data resulting from stress investigations of the cable dielectric under d.c. conditions are also given in the paper.

The ±400kV cable described in the paper has been developed at " Moscable " works and is designed to be suitable for connection into an 800kV transmission system and to carry 900A. To allow for service overvoltages and field tests the cable is designed to withstand 1000kV for one minute. The mean impulse voltage strength of the cable is 1250kV, standard wave, which exceeds the discharge voltage of the protective devices in the line. The cable, terminals, and joints were designed to have a breakdown voltage of 1500kV, d.c. after one minute. Accordingly the values of insulation thickness chosen for the two cables were 18mm for the solid cable and 16mm for the oil-filled pipe cable. The conductors in the two cables are, respectively, 1000 square millimetres aluminium and 550 square millimetres copper.

The aluminium conductor is made up of sixty-one wires of 3·8mm diameter with an outer layer of thirty-six wires of 3·1mm diameter. A screen of three metallised unperforated paper tapes (two 15mm thick and one 0·07mm thick) is applied over the conductor. The paper insulation is made up of tapes of varying thickness. Two metallised perforated tapes and one of perforated aluminium are applied over the insulation. The sheath is of copper-bearing lead and is protected by coverings of bituminous compound, p.v.c. tapes and pre-impregnated paper and jute.

In the alternative oil-filled steel-pipe cable the 550 square millimetre conductor consists of ninety-one copper wires of 2·78mm diameter, lapped with three unperforated metallised tapes as for the other cable. Again the paper thickness is graded. The insulation is covered with two perforated metallised tapes (0·07mm and 0·15mm diameter respectively) and a perforated copper tape.

In paper No. 212 Tellier *et al* reported the results of a systematic study of the behaviour of d.c. cable dielectrics allowing for the effect of temperature on dielectric resistivity. Among the results quoted were families of curves showing the maximum power that can be transmitted with various cable dielectrics. In addition the paper discussed the possibilities of applying forced cooling to a.c. cables designed for very high voltages. In particular, this idea has been applied to the manufacture and testing of a 100m length of 500kV cable with a rating of 1410MVA, and a conductor cross section of 405 square millimetres. Without forced cooling the rating is reduced from 1410MVA to 520MVA. The oil is circulated by a pump through the central duct which is normally provided in an oil-filled cable and is passed through an external cooler. In the cable referred to here the paper insulation has a radial thickness of 28mm.

### Plastics Insulation

Two of the papers discussed dealt with the use of plastics for the insulation of high voltage cables.

In paper No. 207 Vos and Vermeer gave details of some interesting experiments with cable dielectrics, consisting of plastics films or tapes (instead of extruded plastics) in which the film surface had been roughened to allow the dielectric film to be impregnated with oil in much the same way as would obtain with paper dielectric. Experiments have been made with films of polyethylene terephthalate and polystyrene and several methods of roughening the surface have been tried. They include etching, scratching with emery paper and grooving in a machine such as the Schreiner rolling machine which is well known in the textile industry. The authors' main conclusions are that, with dielectrics so treated, ionisation does not begin at stresses below 80kV to 100kV per millimetre, the exact value depending on film thickness ; that the power factor is constant and is inde-

pendent of temperature up to about 80 deg. Cent. and of field strength up to 50kV per millimetre ; and that the d.c. breakdown strength is about 350kV per millimetre.

At present the main limitation appears to be the power factor of the high-polymer film, but, on the assumption that materials combining high temperature resistance with low power factor (say, less than 0·001) may be developed in the near future, an operating stress of 25kV per millimetre or more may become feasible without the use of high oil pressures or very thin tapes.

Two possible alternatives remain to be examined. The first is the use of gas under pressure, in association with a high polymer film. The second is the use of a liquid with high permittivity and low power factor in combination with plastics film, in which case the liquid (which is the weaker component) will be relieved from stress to the extent that its permittivity is higher than that of the solid film.

Experience with extruded polythene cables was given in paper No. 209 by Mildner and Humphries, who examined the mechanisms of dielectric breakdown and discussed the philosophy of type tests and quality control tests to ensure that a cable with plastics insulation could meet installation and service conditions. The authors' experience suggests that economic production should be possible of a core substantially free from discharges at stresses up to 45kV to 50kV per centimetre, which would imply maximum operating stresses of the order of 30kV per centimetre. For economic reasons it might be desirable to limit the wall thickness to 0·3in unless multi-coverings were used. The company concerned has manufactured a few hundreds of miles of 11kV cables to such standards, and substantial lengths of cables insulated with polythene, for service at 15kV and 20kV and smaller quantities at 33kV. Accordingly, the authors concluded that the limit of development for plastics-insulated cables in their present (extruded) form is 33kV, three-phase, a.c., while d.c. cables may be practicable for operating voltages up to 200kV to earth.

In the final group, there were five papers concerned with special studies of high-voltage a.c. cables.

In paper No. 202 Priaroggia *et al.* concluded that, for 400kV, a.c. transmission, the low-pressure, oil-filled cable was better than the high-pressure cable. They showed that the good performance of the high-pressure dielectric at 400kV could not be exploited because of the adverse effects of the increase capacitance when the wall thickness was reduced. However, the paper did not examine the economic consequences of adopting greater wall thicknesses.

A 300kV, oil-filled cable installation was described in paper No. 203 by Bödtker and Johnsen, who included some interesting "echograms" obtained from tests on the cable.

Various methods of detecting and assessing discharges in cable dielectrics were examined in paper No. 204 by Kreuger, who concluded that the true inception voltage in a dielectric was better than the ageing test for assessing the merits of a cable.

Forced oil cooling is the basis for the design of an a.c. cable with a rating of 1000A at 524kV, described in paper No. 213 by Bror Hansson.

### Discussion

G. Palandri (Italy) suggested that there was a demand for a submarine cable without a metallic sheath. Turning to the question of the manufacture of continuous cable without joints, he said that such a cable was an attractive proposition, but that some of its advantages had been lost because of recent improvements in the making of flexible joints. For example, the company with which he was associated had developed a flexible joint for a single-core, 132kV submarine cable.

Discussing the flat cable described in paper No. 201, A. L. Williams (British Insulated Callender's Cables, Ltd., Great Britain) said that it was rather naive to suggest that oil and paper constituted homogeneous materials. He asked the authors of the paper whether joints in flat cables had been subjected to bending and twisting during laying.

C. C. Barnes (Central Electricity Generating Board, Great Britain) said that the pre-impregnated, gas-filled cable operating with 100kV between positive and negative had been considered for the cross-Channel cable, but the choice had fallen upon a solid cable of 340 square millimetres cross-sectional area with a continuous rating of 160MW, joints being made in mid-channel. It was hoped to lay two single-core cables from Britain and to join them to two similar cables laid from the French side, both cables being laid close together to avoid magnetic effects. Flexible joints in each cable length gave promise of proving satisfactory.

The view that plastics would eventually provide the best insulation for submarine cables was expressed by R. C. Mildner (Telegraph Construction and Maintenance Company, Ltd., Great Britain). He referred to tests made in Sweden at 100kV to earth on a cable insulated with a 5mm radial thickness of polythene, and the inference was that a thickness of 7½mm would be enough for a working voltage of 100kV to ground.

On the basis of present-day experience, however, a different choice for a submarine cable was recommended by E. L. Davey (B.I.C.C., Great Britain), who suggested that for depths up to 100 fathoms the gas-filled cable was superior to others. It could be designed for a high electric stress and current rating and could be made in lengths up to 20 miles for any voltage that might be required. For a submarine cable with "solid" insulation he preferred solid setting compounds, which eliminated troubles caused by compound migration and prevented ingress of water. He believed that, while plastics could not be used as yet, they offered considerable promise for the future, particularly at depths of more than 150 fathoms. Mr. Davey then turned to the subject of the mechanical protection for cables subjected to specially onerous submarine conditions. His recommendations included the following :—The use of lock type armouring to limit bending over submarine rocks more than 20ft high ; a comparatively low value of the ratio of immersed-weight/diameter ; and the use of armouring having high abrasion resistance where strong tides may be expected. An important precaution was that the cable should be torsionally balanced so that it would not twist during laying. Compensating torsional resistance could be introduced by counter lay of armouring wires or tapes ; torsional resistance was specially important over long unsupported spans.

Yet another viewpoint on the choice of a cable for submarine working was expounded by C. T. W. Sutton (Enfield Cables, Ltd., Great Britain). He agreed that, fundamentally, a cable without joints appeared to offer the ideal solution, but he strongly disagreed with criticisms which had been made of flexible joints. Ultimately plastics insulation would answer the requirements of a submarine cable, but that was a matter for the future. Mr. Sutton asserted that, as an alternative to the cable ship there was much to be said for the method of cable laying by drum, as has been done with "Pluto" and, later by Danish cable engineers.

Another aspect of the cable-laying operation was discussed by A. Bergman (Swedish State Power Board), who emphasised the importance of checking the tension of the cable during laying. This tension depended very much upon the speed of the cable ship in relation to the sea bed and a great deal of attention had therefore been devoted to developing methods of measuring this relative speed accurately. A promising system had been worked out, making use of Decca navigators and the chains of Decca stations and experiments had been carried out during the laying of about 100km of 100MW cable between Gottland and Sweden.

Replying to criticisms of paper No. 201 A. M. Morgan (Enfield Cables, Ltd., Great Britain) declared that since the last report on the subject (C.I.G.R.E., 1952) there had been many more installations of the flat two-core cable and that details of these installations were of general interest. On the specific question of the testing of flexible joints his answer was that such joints which formed part of cable installations had been effectively tested, *in situ*, for years.

Discussion of the second group of papers —those dealing with high-voltage direct-current cables—ranged around three main questions : First, can any conclusion be reached about the maximum gradient which is likely to determine the limiting performance of d.c. dielectrics ? Secondly, is it reasonable to accept the conclusions reached in the papers that there is a finite limit to the power which can be transmitted by high-voltage d.c. cable insulated with a given dielectric ? Thirdly, are there any indications of the relative merits of plastics-insulated cables and impregnated-paper-insulated cables for high-voltage d.c. transmission ?

R. C. Mildner (Telegraph Construction and Maintenance Company, Ltd., Great Britain) referred to some accelerated ageing tests that had been carried on polythene-insulated cable. Such a cable had withstood 100 reversals from 100kV to −100kV, first at 80 deg. Cent. and subsequently at 60 deg. Cent. Then, on being subjected to a further, similar, test cycle at 80 deg. Cent. the cable had failed after 200 reversals.

E. L. Davey (B.I.C.C., Great Britain) said, vis-à-vis the limiting performance of high-voltage d.c. cables, that stress and temperature gradient were interdependent. Turning to the comparative performance of cable dielectrics he gave the results of some tests on a solid-type cable with 7½mm radial thickness of insulation impregnated with a solid setting compound. This cable withstood without distress 100 reversals, first between 130kV and −130kV and then between ±600kV d.c.

D. H. Booth (W. T. Glover and Co., Ltd., Great Britain) described a form of construction which his firm had developed mainly for voltages of 33kV and above, making use of plastics film only in the highly stressed parts of the insulation and paper elsewhere. Solid cables insulated in that way, for 22kV and 33kV, had been in service since 1952. The 22kV cable was for traction supplies and was supported on posts. In these cables polystyrene had been used for the inner, more highly stressed, insulation zone (16kV per millimetre in the case of the 33kV cable). For this kind of application "Terylene" was a possible alternative to polystyrene, but its price would have to fall by 75 per

cent before it could be economically competitive. On the other hand, some of the physical properties of polystyrene, including its thermal qualities, had been improved recently. Other possible alternatives that were being examined by his firm included polypropylene and irradiated polythene, but there was no evidence yet that these materials offered any advantages.

The suggestion that, at temperatures up to 70 deg. Cent., polythene was better than polyethylene as a cable dielectric was made by Cassana (Italy). On the basis of experiments made by his firm he maintained that gas was superior to oil for impregnating lapped plastics.

C. C. Barnes (Central Electricity Generating Board, Great Britain) said that for voltages above 11kV polythene was of the greatest importance as a cable dielectric and it should be suitable for operation at d.c. voltages of at least 200kV to earth.

G. de Zoeten (K.E.M.A. Laboratories, Netherlands) expressed the view that the value of 60 deg. Cent. specified (in Mildner's paper, No. 209) for the maximum working temperature was too conservative, since 90 deg. Cent. was permissible. However, by accepting the lower figure as the normal operating temperature a greater margin would be available for temperature rise.

S. Smedsfelt (Swedish State Power Board) referred to 11kV submarine cables, up to 20km long and having plastics insulation without armouring, installed and in service between islands in the Stockholm archipelago.

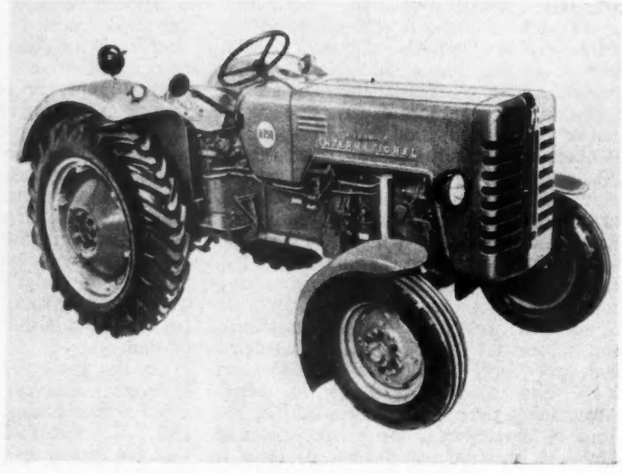
In a brief reply to questions raised in the discussion R. C. Mildner explained that existing applications of plastics-insulated cables in Great Britain had been for special service, such as in aerial or submarine installations. If gas pressure was to be relied upon for the suppression of ionisation then extruded insulation would probably be preferable to tapes. He felt that, for plastics-insulated cables, a fair operating limit was 200kV to earth, although he had had cables operating at voltages up to 300kV to earth.

De Vos who replied on behalf of his co-author Vermeer asserted that, for very high voltages insulating films of plastics should be combined with oil rather than gas. Dealing with the economics of cable insulation, he said that at present prices plastics cost about twenty times as much as the equivalent paper insulation and that the corresponding ratio of the costs of the completed cable was about 2 : 1. He suggested that the working value of the voltage gradient could be taken as 25kV per millimetre.

*(To be continued)*

# Royal Show at Bristol

*The 110th Royal Show opened at Bristol on Tuesday and closes this (Friday) evening. It is arranged on a site extending over 157 acres, a large proportion of which is occupied by the 590 or so stands displaying all kinds of farm machinery and equipment. It is interesting to note that in the machinery section there are several examples of tractors and tractor-operated equipment suitable for work outside the normal run of farming. But the majority of the exhibits, of course, demonstrate the progressive development of mechanised agriculture throughout the world.*



FOR the fifth time in its history, the annual show of the Royal Agricultural Society is being held at Bristol. It is a centre around which both agriculture and industry are extensive, and whilst, of course, the show continues to be a national event, its setting this week is one that is enriched by some West Country characteristics. As usual, machinery of many kinds is predominant. Ever since the " Royal " was started in 1839 farm implements have had an important place in it, and the four shows previously held at Bristol have each, in their turn, exhibited some new development in mechanised agriculture.

When, for example, the Royal Show went to Bristol for the first time, in 1842, there was Lady Vavasour's invention of a " rotary tiller," to which we referred on page 956 of our last issue. The next occasion was in 1878, when there were numerous steam portable and traction engines to be seen. There was also exhibited by Richard Hornsby and Sons " the only new implement designed to do work hitherto accomplished by hand." It was a hedge cutting machine, " worked by two horses, a youth to drive, and a man to control the cutting." A drawing of this machine indicates that its arrangement was in many respects similar to that of its tractor-mounted successors exhibited at this year's show. There was a gap of twenty-five years before the " Royal " visited Bristol again. The year was 1913, by which time the possibilities of internal combustion engine power on the land were—to say the least—being cautiously considered. We commented on the " further increase in the number of self-propelled farm implements " and gave particular attention to a two-furrow motor plough introduced by John Fowler and Co. (Leeds), Ltd. This plough was fitted with a single-cylinder vertical oil engine of 4 h.p. which, we were careful to point out, could be used for all kinds of stationary work when the plough was not required in the fields. The plough had two driven road wheels and the attendant walked in the rear " manipulating the engine and plough by means of star wheels." The last Royal Show at Bristol, prior to the present one, was in 1936, by which time the number of horse-drawn implements exhibited was definitely declining. There was a variety of tractors, one or two combine-harvesters, at least two grass drying plants and there was a 40 h.p. oil-engined " Gyrotiller."

But the comparison between the machinery exhibits at the shows formerly held at Bristol and those which form such a large part of this year's show is a striking one ! Tractor design and efficiency have reached a high standard, tractor-operated and self-propelled machines for almost every agricultural task and for many " off the farm " uses increase in number and novelty, and electrical equipment of many kinds has an important place. Alongside numerous exhibits of this nature which typify the progress of agricultural engineering, there may also be seen at Bristol several examples of traditional rural crafts which are still skilfully practised in many parts of this country.

## Tractors

Towards the end of last year several new tractors were introduced by British firms. They were exhibited for the first time at the Smithfield Show in December (THE ENGINEER, November 29, 1957) and are now in production by their respective manufacturers. Examples of these tractors naturally have a prominent place at the Royal Show, and one of them, the " Dexta," made by the Ford Motor Company, Ltd., was awarded the Royal Agricultural Society's silver medal.

There are also to be seen, of course, examples of the many other wheeled and crawler tractors, of small, medium and large powers, which are available for agricultural and industrial work. An interesting tractor development which comes into the latter category is illustrated at the head of this article. It is an industrial version of the B-250 wheeled tractor which has lately been introduced by International Harvester Company of Great Britain, Ltd., 259, City Road, London, E.C.1. The agricultural version of this tractor was described in our issue of December 9, 1955. The industrial B-250 has a four-cylinder diesel engine of 30 b.h.p. and is equipped with a differential lock to prevent wheel slip. There are two independent braking systems, namely, hydraulically controlled and disc braking. The makers are producing three industrial models of this tractor ; one of them is a draught tractor

employing a swinging drawbar but without hydraulics, and in the other two, hydraulic equipment with and without three-point linkage is incorporated. For the operation of power-driven equipment, the industrial B-250 has been designed to conform to the British Standard for power take-off speeds.

A tractor development shown by David Brown Industries, Ltd., Meltham, Huddersfield, is a rear power take-off unit and drawbar extension for the "2D" tractor. The "2D," it may be recalled, is a tractor which has a 14 b.h.p. diesel engine at the back, the implements which it operates being centrally mounted in front of the driver. The equipment of the tractor includes a power take-off shaft situated in front of the gearbox and facing forward into the centre of the mounted implement space. The provision of a rear p.t.o. shaft enables implements such as drills, small manure spreaders and trailed sprayers to be operated by the tractor. The input shaft of this new p.t.o. unit is coupled to the front end of the engine crankshaft and the output shaft revolves in the same direction as the engine; the p.t.o. speed is 530 r.p.m when the engine is running at 1500 r.p.m. The output shaft is operated by a hand brake which is actuated by a small air ram built into the p.t.o. casing. Compressed air is supplied from the main frame of the tractor which serves as a reservoir both for the power take-off and air lift systems. The extended drawbar is, of course, required for the attachment of rear-coupled p.t.o.-driven implements. The arrangement of the p.t.o. shaft and of the drawbar is illustrated in Fig. 2, which also shows a "2D" tractor fitted with "Rowcrop" wheels made by E. Allman and Co., Ltd. The tyres are 4in by 36in and there are extension plates for repositioning the tractor mudguards. As well as enabling the tractor to work in narrow rows, the fitting of these wheels provides an extra 5in ground clearance. Another addition to the "2D" tractor is a rear-mounted pulley which is bolted to the engine and driven direct from the crankshaft; it incorporates a centrifugal clutch which engages automatically when the engine reaches a speed of 700 r.p.m. and disengages when the engine speed falls below that figure. A 6in diameter crossed pulley is used and the unit is designed for a belt speed of 1340ft per minute at an engine speed of 1400 r.p.m.

Recent improvements in the design of tractors include the provision of independent control, by a single pedal, of the main drive from the engine to the wheels and the power take-off. A new Borg and Beck 10in integral main drive clutch and power take-off is exhibited by Automotive Products Company, Ltd., Leamington Spa. In this assembly there are actually two separate and independent clutches which are mounted in tandem within a single pressed steel cover. The cover contains the main and intermediate pressure plates. A single ball-thrust release mechanism provides for the operation of both clutches. The clutch adjacent to the flywheel controls the drive to the power take-off, whereas the outer clutch operates the main drive through a hollow shaft through which the power take-off shaft passes. The two clutch-driven plates are similar with the exception of the size of their splined hubs which respectively engage the solid power take-off and the hollow main drive shafts; they are fitted with heavy-duty woven metallic friction facings. As to the operation of the unit, with the pedal in the free position, both the main drive and the power take-off clutches are engaged. When the pedal is depressed to an intermediate position the main drive clutch is disengaged, but full torque continues to be transmitted to the power take-off; full depression of the pedal disengages both clutches, allowing the engine to run free of load.

### Tillage and Other Implements

The Royal Show is an occasion when one cannot fail to be impressed by the number and variety of the implements and machines now used by farmers all over the world. Many of them are specially designed for operation by particular tractors, many are suitable for use with a number of different tractors and some are "self-propelled" in that they are equipped with their own power units. Among the new implements, designed for the Fordson "Dexta" tractor, on the stand of Ransomes Sims and Jefferies, Ltd., Ipswich, there are some examples of mounted reversible share ploughs. The plough bodies are reversed and locked in position automatically by a double-acting hydraulic ram, and since the action of this ram is independent of the tractor's hydraulic lift the plough can be raised at any time without reversing the bodies. No mechanical locking device is necessary as the hydraulic system of the tractor maintains identical working positions for each run. There are two versions of this plough, one, a single-furrow implement, primarily intended for deep work, being fitted with bodies for furrows up to 12in deep and 12in to 16in wide, and the other (Fig. 1) a two-furrow plough, which will work to a depth of 10in. There is also a two-furrow disc plough, the reversing mechanism of which is similarly operated by a double-acting hydraulic ram.

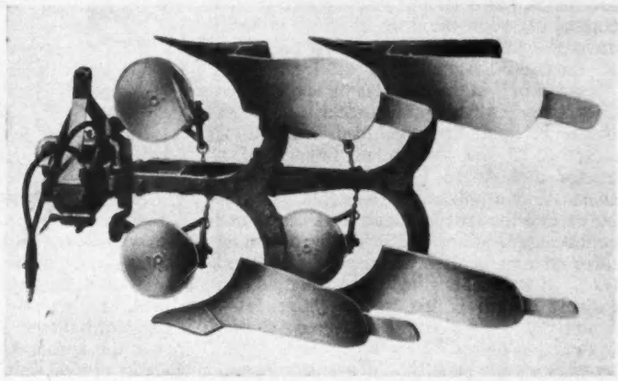


Fig. 1—Two-furrow reversible plough

New tillage implements exhibited by David Brown Industries, Ltd., include the "Albion" combined ripper and mole drainer (Fig. 3), which is one of the products of Harrison, McGregor and Guest, Ltd., Leigh, Lancs. This is the kind of implement used for such tasks as loosening the subsoil below the normal ploughing depth, breaking up "hard pan" in tropical areas, mole draining, and the forming of shallow trenches for "trench manuring" as practised in many vine growing areas. The implement can be easily converted from ripping to mole draining merely by reversing the reinforced main beam. It can also be used for trench making by bolting two "ditcher" wings to the ripper end of the main frame. The combined depth wheel and disc opener can be adjusted to give a selection of working depths between 12in and 20in. The disc prevents choking of the wheel by top trash and assists rapid penetration of the reversible ripper share, which is 12in long. The 2in

Fig. 2—Rear p.t.o. shaft and drawbar extension on the "2D" tractor.

Fig. 3—Combined ripper and mole drainer

diameter steel mole is provided with a steel " follower " or expander of 2½in diameter.

On several occasions we have referred, in connection with the Royal Show and other exhibitions, to the Howard " Rotavator," which is made by Rotary Hoes, Ltd., West Horndon, Essex. This year the firm is exhibiting a new model which is equipped with a " Selectatilth " gearbox. There is also shown a new application of the Howard " Rotavator " combined with an Allman " Speedesi " duster and a booster fan. This equipment, known as the " Auchincruive " soil mixer, has resulted from research on the control of soil borne diseases which is being directed by Dr. John Grainger, of the West of Scotland Agricultural College. The " Rotavator " in this case has three duck-foot tines, each 9in wide. The duster is mounted above it, and the combined machine is attached to the three-point linkage of a tractor and driven by the power take-off shaft. For application in depth, dust is blown into the spaces behind the three tines ; surface applications are made by deflecting three streams of dust which meet at ground level. If a diesel-engined tractor is used, the exhaust stream is led to the " Speedesi " duster where it picks up a measured quantity of dust and passes it to a fan which is driven by an extension from the " Rotavator " gearbox. The flow of dust and gas is thereby boosted, back pressure on the engine exhaust is reduced, and the dust is evenly mixed with the exhaust gas.

The automatic potato planter illustrated by Fig. 4 is one of a number of new items shown by Massey-Ferguson, Ltd., Coventry. The planter is one of the implements designed for use with the Massey-Ferguson " 35 " and " 65 " tractors ; it can be raised and lowered by the tractor's hydraulic system but its drive is taken from its land wheels. There are two hoppers, each of 3 cwt capacity. Within each hopper there is a partition which incorporates an adjustable slide to control the flow of potatoes to a feed disc. As indicated by Fig. 5, each feed disc is fitted with twelve equally spaced, spring-loaded, roller operated fingers which pick up the potatoes. As the disc rotates, the action of the rollers against a cam rail causes the fingers to open and grip the potatoes which are carried round and released over the aperture of the planting chute. As the potatoes fall to the ground they are covered by the action of angled

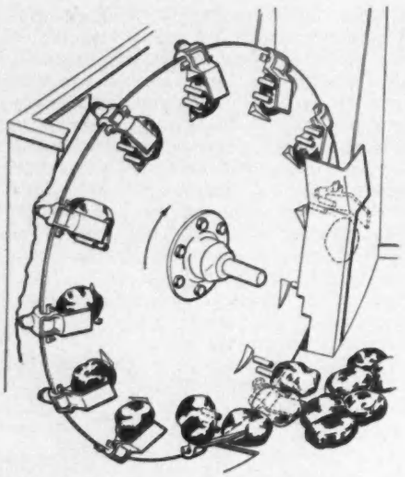


Fig. 5—Potato planter feed mechanism

discs which are adjustable for width. The planter can be adjusted, in 2in steps, to give row widths from 24in to 30in. To give varying seed spacings between 10in and 18in, a range of half-sprockets is provided ; when in use the sprockets are bolted to the axle shaft in one of four positions. Attached to the back of the planter there is a steerage fin which penetrates firm soil beneath the tilth and thereby, in effect, compels the implement to follow the course set by the tractor's front wheels. A fertiliser attachment can be fitted, as shown in Fig. 4, between the tractor and the planter. It consists of a hopper in the bottom of which there is arranged a fluted sleeve, forced feed delivery mechanism driven by chains and sprockets from the left-hand rear wheel of the tractor. Agitator plates in the hopper prevent the fertiliser from bridging over the feed mechanism and ensure a constant rate of distribution. From the distributing mechanism, the fertiliser falls through flexible tubes into placement coulters which are situated ahead of the potato delivery chutes. The fertiliser feed mechanism is controlled by a hand-operated clutch.

Adequate irrigation is an essential of successful tillage ! There is some interesting irrigation equipment among the exhibits at Bristol. An example of this kind of equipment is the tractor-mounted " Raingun " (Fig. 6) produced by Farrow and Sons, Ltd., Spalding, Lincs. Hitherto, the customary method of watering tall crops like hops, sugar cane and fruit trees has been by rigging up sprinklers on tall tripods. The business of moving such assemblies from one point to another is not an easy or a convenient one. The " Raingun " has been designed with the idea of overcoming this problem. There are two models, designated Nos. 70 and 100, and, it is claimed, they can provide an even distribution of " rain " over 2½ acres and 3 acres respectively from a single position. The " Raingun " is screwed into a tail pipe which is welded to a bipod and the bipod is fixed, with the standard pins, to the arms of a tractor-mounted high-lift loader. The retaining springs of the loader are attached to the bipod, as also is the slave ram, by means of a

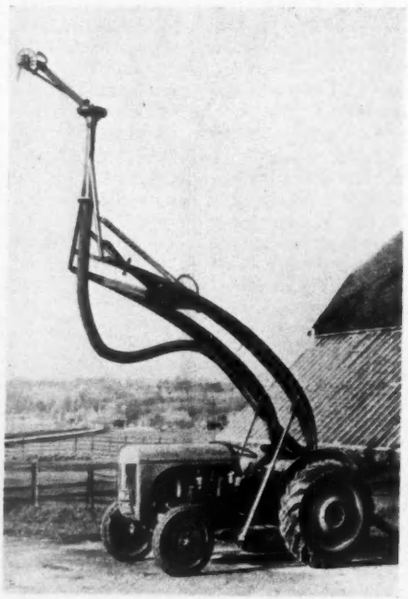


Fig. 6—Tractor-mounted irrigation gun

hinged arm ; the slave ram holds the " Raingun " in the upright position during operation at any height. The gun is fed from the main pipeline by " Plastidry " flexible irrigation hose which is coupled to the tail pipe. A single-stage centrifugal pump has been developed by Farrow and Sons, Ltd., for use with the " Raingun." It is operated by tractor power take-off and incorporates a combined delivery and non-return valve. Typical duties are said to be 200 g.p.m. with a head of 280ft and 340 g.p.m. with a 250ft head.

Field irrigation equipment is also shown by Wright Rain, Ltd., Ringwood, Hants. In addition this firm is exhibiting its " manure-rain " mixing and distribution system. It is claimed that this system enables the maximum benefit to be obtained from all farmyard manure without any wastage of the liquid or loss through storage and ammonia generation ; furthermore, the expenditure involved in the conventional methods of loading and distributing manure is avoided. The essential equipment for the " manure-rain " system comprises a collection tank with a mixer-cutter and pump and standard irrigation piping and sprinkler. The collection tank, normally built of concrete, is fitted with a paddle agitator turning at about 15 r.p.m., the power required being 1 h.p. for each 6ft length of paddle shaft. For a start, water is run into the tank to a depth of 2ft and unless the manure supply is in a particularly " loose " state the contents of

Fig. 4—Automatic potato planter

the tank are stirred for about ten minutes twice a day. The stockyard drainage goes directly into the tank. If there is long straw in the manure a mixer-cutter is essential ; it is placed near to the collecting tank and needs about 5 h.p. for its operation. A mixture of water and liquid manure is fed into the mixer-cutter to maintain a constant level of liquid, the straw is drawn into the mixing chamber by the flow of the liquid and is then sucked up into a central outlet pipe. At the entrance to this pipe there is a four-bladed cutter working at 1000 r.p.m., which chops the straw into short lengths as it passes in the liquid.

The distribution part of the system includes a piston pump incorporating an automatic overload valve which channels the flow back to the suction side when necessary, thus permitting a discharge valve to be closed as with a centrifugal pump. The power requirement varies from 3 h.p. to 50 h.p. according to the size of pump and its duty. Where the duty is light, with distribution over short and level distances, an open-vane centrifugal pump can be used. The liquid-manure mixture is pumped to the point of distribution through ordinary irrigation piping. At the discharge point a hand-directed thrower or a " Vector " sprinkler can be used, on a simple wheeled carrier if required. The

**Fig. 7—Hydraulic tipping trailer for silage harvesting**

sprinkler is operated as for normal irrigation, except that the interrupter blade at its nose is adjusted to remain out of the jet stream, and the straightening vanes in the nozzle tube are removed. Its automatic sectoring action can be set for any desired angle by movable stops on the control ring.

Some other machinery which is much in evidence at this year's Royal Show is that which is now being produced for green crop cutting for silage making. A working demonstration of this class of machinery was held recently and some of the equipment shown there was described in our issue of May 30. Loading and carrying the cut crop are naturally an important part of the operation and various trucks and tipping trailers specially adapted for this work are exhibited at Bristol. One of them, built by Taskers of Andover (1932), Ltd., Andover, Hants, is illustrated by Fig. 7. It is a 3-ton two-wheeled hydraulic tipping trailer fitted with detachable " silage extensions " with a rear gate hinged at the top. These extensions are made of expanded steel mesh set in steel angle framework. The tipping gear is operated hydraulically from a tractor by means of a two-stage ram located under the trailer body. The tipping pivot point is at the extreme end of the main frame. A hand pump can be fitted for tipping the trailer when it is disconnected from the tractor or when it is being towed by a vehicle not provided with hydraulics.

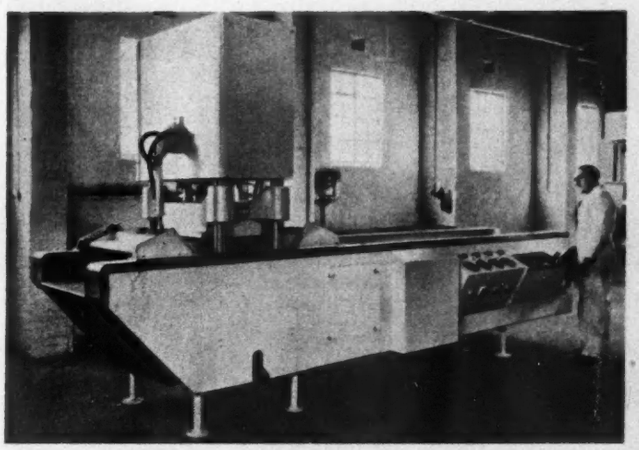
### Silver Medal Awards

Every year, the Royal Agricultural Society awards silver medals for machines and implements which have definite application to agriculture, horticulture or estate service and are " new in principle or purpose." All the entries for silver medals undergo detailed tests before they are judged by a panel appointed by the Society. This year there were thirty-one entries, of which sixteen were accepted for judging. The following awards of silver medals were announced at the opening of the show on Tuesday morning :

David Brown Industries, Ltd., rotary tiller ; Eastern Counties Farmers, Ltd., tractor-drawn pea cutter and viner (for which the Burke challenge cup was also awarded) ; Ford Motor Company, Ltd., " Dexta " tractor ; Limemaster, Ltd., lime and fertiliser transporter and distributor ; Ransomes, Sims and Jefferies, Ltd., trailer disc harrow.

## Automatic Conveyor Press

An automatic self-feeding conveyor press adaptable for the extraction of water, oil or juices from a variety of fibrous, fibro-granular and granular materials has been developed by



**Automatic conveyor press equipment used for tests on materials to provide data for developing production machines**

Modern Mechanisation, Ltd., 52, Bounds Green Road, London, N.11. This machine is based upon a press developed to the designs of Mr. N. W. Pirie and built by the company for the Rothampstead Experimental Station where it was required for the extraction of protein from green leaves. A photograph we reproduce on this page shows one of the new press equipments which has been installed at the maker's works for research purposes. It is also used for carrying out trials on various materials to determine the potential of the press for their particular requirements and finalise design features of an installation when these requirements have been ascertained.

The press is intermittently continuous in operation, material being fed into it by means of a conveyor belt which also acts as a filter cloth. Succeeding quantities of material are isolated below the press ram by gates and then subjected to a controlled pressure for a predetermined length of time. In this way, the equipment, although not strictly continuous, functions as a continuous machine.

The machine consists of a hydraulically operated, down-stroke platen press with an 8in deep trough-shaped bed through which a closely fitting conveyor belt passes. This belt is made of a filter cloth of a suitable textile material and it is moved along between press strokes by a 24in stroke hydraulic ram. Hydraulically operated gates on each side of the press close the open trough ends to form an open topped box into which the press platen fits like a square plug which, as it descends, compresses the contents. At the bottom of this box the conveyor belt is supported on a wedge wire grid which, in turn rests on a heavy cast grid designed to take the full load imparted by the press ram on the material in the box. Liquid forced out of the material by the descending ram is forced through the conveyor belt and grid and gravitates into a collecting tray below. This collecting tray can be connected by a short pipe to a suitable receptacle in a process pipeline. At the ingoing side of the press there is a troughed feed section along the floor of which the conveyor belt runs. The material to be processed is fed on to this section and levelled to the required depth before it reaches the pressing station.

The standard press has a 24in square platen with a 7in stroke, and a rubber pad over the platen accommodates irregularities in the density of the material on the belt. Platen pressure is adjustable up to about 300 lb per square inch, and if required, this figure can be increased to 450 lb per square inch. Pressure can be maintained on the material in the box for periods adjustable up to five minutes under the control of an electrical timing device.

Electro-hydraulic sequence valves control the automatic cycle of the equipment which starts when the press is at the top of its stroke. At this point the belt ram in a period of two seconds draws the belt along the trough to carry a new charge into the pressing station. When the belt stops the press end gates close to isolate a section of material and the platen descends at a preset speed to build up pressure at a controlled rate to the predetermined maximum. This control of platen approach speed obviates splashing when dealing with very soft or pulpy materials, and controlled pressure build-up speed facilitates maximum liquid extraction when dealing with certain materials.

The makers state that the output of a pressing equipment of this design depends upon the pressing period and the depth of bed used, and can only be determined by experiment. The maximum output using a full depth load of 6in of material on the belt is 2 cubic feet per operating cycle. Experience has shown that four cycles per minute are possible when allowing a pressing time of about ten seconds. This would give a throughput of some 480 cubic feet of raw material per hour with maximum belt loading.

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Cutting Efficiency of Files.—We are informed by Acheson Colloids, Ltd., 18, Pall Mall, London, S.W.1, that tests carried out jointly by William Jessop and Sons, Ltd., and J. J. Saville and Co., Ltd., the Sheffield steel and tool manufacturers, have shown that molybdenum disulphide treatment of files can improve their cutting efficiency by as much as 60 per cent. A " dag " dispersion of colloidal molybdenum disulphide was used throughout the tests.

Primer for Wet Metal Surfaces.—A recent addition to the products of Allweather Paints, Ltd., 36, Great Queen Street, London, W.C.2, is a corrosion inhibiting zinc rich metal primer for application to iron and steel surfaces which are wet or moist and which cannot be dried before painting. It is stated that " Pitanode Wet," as it is known, can be applied under almost any conditions to site steelwork and for the maintenance of iron and steel equipment already in service. It can be applied over small amounts of firmly adherent rust and when in contact with iron or steel under corrosive conditions, affords electro-chemical protection. Protection is effective along the edges of any break in the zinc coating ; thus small cracks or pinheads present in the coating due to abrasion or faulty application may result in rusting which is purely local where the metal is exposed, but no progressive sideways corrosion takes place under the coating.

# LETTERS AND LITERATURE

## Letters to the Editor

*(We do not hold ourselves responsible for the opinions of our correspondents)*

### RAILWAYS INTO ROADWAYS

SIR,—In the *Sunday Times* of May 19, 1957, W. Tatton Brown said that "The American is no longer a free man in a vast continent, but a prisoner of the petrol engine. For the extreme mobility which the possession of a car affords him has also been bestowed upon his neighbours. The more of them that have cars the less use is his." If the Railway Conversion Scheme materialised the Englishman would find himself in a similar plight. Instead of blindly following the Americans we should see first of all whether or not we are putting our heads in the fire. We should also remember that America has natural supplies of oil, whereas we haven't. The more we depend on imported fuel the more we place ourselves at the mercy of our enemies. Will the lesson of the Suez crisis never be learnt ?

As well as *Twilight of the Railways* I have also read *It's High Time to Put an End to Traffic Congestion*, a booklet published in Brussels by the International Union of Public Transport. This book states that the use of private cars in the central areas of cities in their present form, especially their use for journeys from home to work, is a luxury which no city can afford to provide on an unlimited scale. The I.U.P.T.'s solution to the traffic problem is not to create more and wider roads for more vehicles, but to get more vehicles off the existing roads. There are many ways of doing this and some are described in this booklet. Until we get the "movement of people" in mind, rather than the "movement of private vehicles," we will never solve the traffic problem.

It seems to me that we desperately need an Anti-Railway-Conversion League. If anybody is interested in helping me start such a body, I should be glad to hear from them. The first aim, of course, would be to publish an answer to *Twilight of the Railways*.

DENNIS GILL

Hazel Grove,
Cheshire,
June 26, 1958.

SIR,—Having read the correspondence, it is apparent that conversion of main line railways into trunk roadways is not practical. First, instance a passenger in a hotel at *A*, some 200 miles from London, where he has an appointment at 10.30 a.m. He leaves his hotel at 7 a.m., joins a main line express, reads his paper in comfort, is called to the dining car at 8.30, has a breakfast, makes notes for his appointment, has a wash and arrives in London fresh and clean for his meeting. Does the same journey by coach merit comparison ?

Secondly, consider only the mail service. The mail between London and Scotland, during January to March, fifty coaches in each direction, 200 drivers (one could not do the whole trip), and one skid over Shap ! Dare one mention the Christmas and New Year Mail ? If conversion became a fact, one can envisage some future Brigadier conceiving the idea of coupling a series of coaches together, mounting the whole thing on rails, and using as motive power the cheap, nuclear generated electricity.

By all means eliminate every uneconomic feeder line, discontinue the use of parallel main lines for mixed traffic, use one for freight only and one for passengers only, increase mechanical handling, improve permanent ways, rolling stock and signalling, to give faster, safer, comfortable and more convenient journeys. Reduce main line station staffs by closing departure platforms to all but travellers. No ! The solution to our traffic problem lies not in conversion, but in the efficient and economic utilisation of our existing network by eliminating the all-too-prevalent oil-lamp mentality and technique.

R. DOBSON

Kidsgrove,
Stoke on Trent,
June 25, 1958.

**America is by no means free from congestion. "Prisoners of the petrol engine" queueing to cross the Delaware River bridge**

## Book Reviews

**Metallurgical Aspects of the Control of Quality in Non-Ferrous Castings.** Institute of Metals, 17, Belgrave Square, London, S.W.1. Price 35s.

THIS book, which is No. 22 of the Institute of Metals Monograph and Report Series, consists of eight papers given at a Symposium held in London on May 1, 1957, with the discussion upon them. The papers are as follows :

"The Metallurgical Principles of the Control of Quality in Non-Ferrous Castings," by R. W. Ruddle and A. Cibula (*British Non-Ferrous Metals Research Association*).

The reasons for the occurrence of defects and the scientific basis of methods for the removal of these are discussed. The main sections cover : (*a*) The flow of liquid metals through the gating system and into the mould cavity ; (*b*) The rate at which castings freeze, the mechanism of freezing in metals and alloys, and the bearing of these factors on the incidence of shrinkage porosity and on methods of freezing. Solidification defects, such as hot tears and segregation, are also considered ; (*c*) Melt quality, including the control of gas content, grain refinement, elimination of non-metallic inclusions and design of test-bars. There are 122 references.

"The Role of Statistical Methods in Controlling the Quality of Non-Ferrous Castings," by A. R. Martin (*Northern Aluminium Company, Ltd.*).

This paper seeks to apply, in the foundry, some of the usual statistical methods of process control. Those most suitable for foundry purposes are discussed, and a consideration of the conventional ways of treating and presenting test data is used to introduce worked examples showing how the most appropriate statistical approach is selected, and the results which may be expected from its application. There are five references.

"Metallurgical Control of Quality in the Production of Aluminium Alloy Castings," by A. V. Carless (*Birmingham Aluminium Casting* (1903) *Company, Ltd.*).

The methods adopted and the precautions observed in controlling the quality of aluminium alloy castings are reviewed, chiefly

from the metallurgical aspect. Dimensional accuracy is not considered. Mould-technique is discussed only when it serves to promote metallurgical soundness. Working procedure and metal treatments are described; also the steps taken to ensure maintenance of metal quality. Methods of assessing soundness, composition and a satisfactory mechanical and metallurgical condition of the product are referred to.

"Metallurgical Control of Quality in the Production of Copper-Base Alloy Castings," by A. R. French (*J. Stone and Co. (Charlton), Ltd.*).

This paper deals with the copper-base alloys included in B.S. Schedule 1400, more particularly those sand-cast. The constitution and the effect of composition and structure on properties are discussed. The effects of impurities and reducing gases are dealt with separately. A section on alloying and melting practice covers the control of metal quality, the tests for which are also considered. The modes of solidification of the two groups into which these alloys fall (the high-tensile brasses and aluminium bronzes, having a narrow freezing range; and the copper-tin bronzes, with a wide freezing range) are considered, and a final section, devoted to the control of casting quality, refers to such factors as gating and feeding. There are 124 references.

"The Control of Quality of Magnesium-Base Alloy Castings," by E. F. Emley and P. A. Fisher (*Magnesium Elektron, Ltd.*).

Practice contributing to high quality in sand castings is considered and an account is given of inspection techniques designed to show that this quality has in fact been achieved. Methods of determining the identity, origin and practical significance of the possible defects are described, so that the appropriate remedy can be applied. Some observations are made as to the production arrangements which can facilitate the attainment of high quality. There are fifty references.

"Control of Quality in the Production of Nickel Alloy Sand Castings," by D. R. Wood and J. F. Gregg (*The Mond Nickel Company, Ltd.*).

The effects are described of small variations in composition on the mechanical properties of alloys of nickel with carbon, silicon, copper, chromium, molybdenum, tungsten and tin, and containing also iron and manganese. Sulphur and lead are deleterious impurities, their effects being less pronounced in nickel-chromium than in nickel-copper alloys. Factors affecting castability and weldability are referred to. The choice of raw materials, melting furnaces and refractory linings is discussed. Melting procedures for electric induction and arc furnaces are described, including the use of "boiling" and oxygen lancing for degassing and refining. By using the second method for nickel-copper and nickel-chromium-iron alloys, metal of high mechanical quality can be obtained from scrap-metal charges, and the weldability of nickel-copper alloys is improved. Successful melting demands the use of highly refractory moulding sands, substantial feeder systems and a mould design permitting unhindered contraction of the metal in both the liquid and solid state. There are eight references.

"The Control of Quality of Pressure Die-Castings," by H. J. Sharp (*Hoover, Ltd.*).

Measures to produce castings of high quality are discussed; these cover the selection of suitable machines and alloys, the detection and elimination of defects, control of metal quality, casting and die design, the maintenance of a suitable heat balance in the die cavity, control of metal flow into the die and the effects of injection pressure. The interaction of these variables with one another is considered.

"Non-Destructive Testing in the Control of Quality of Non-Ferrous Castings" by S. L. Fry (*J. Stone and Co. (Charlton), Ltd.*).

Methods such as visual inspection, liquid penetration, pressure testing, ultrasonic testing and fluoroscopy are briefly referred to. The paper mainly concerns the radiographic examination of castings and the interpretation of the results. Defects detectable in radiographs are illustrated.

These papers clearly constitute a valuable source of reference to foundrymen, but methods of gating and running sand-castings are illustrated only in the comprehensive paper by Ruddle and Cibula. These authors lay down the fundamental requirements of the running system; such as: (1) that it should not allow turbulence in the stream of metal to exceed the point at which agitation occurs (i.e. when the surface is continually being broken and the resulting dross is entrained with air in the metal); (2) that it should be capable of preventing any dross poured with the metal from reaching the mould cavity; and (3) that it should limit the velocity of the metal sufficiently to prevent erosion where the stream impinges on the mould surface. Clearly, however, these considerations affecting the design of the running system apply equally to that of the casting itself. One commonly finds that a casting which constitutes a compact layout from the viewpoint of the duty it has to perform is most difficult to make successfully in the foundry, chiefly because directional feeding cannot satisfactorily be effected. Casting design is a subject not sufficiently covered in these papers. It was evident in the discussion that there was considerable diversity of opinion on a number of matters; among these being how best to control and determine the gas content of the metal before pouring; how to control and determine the fluidity of the metal which is being poured; what determines the grain size of a casting, and the relation of grain size to quality; the extent to which the quality of a casting is shown by the test-bar, and so forth. A study of these papers will be often greatly helpful in the solution of the particular foundry problem which confronts one.

**Van Nostrand's Scientific Encyclopedia.** Third edition. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price £11.

THIS large volume of over 1850 pages provides a comprehensive reference work of the major sciences and fields of technology. Specifically, the 14,800 entries cover Aeronautics, Astronomy, Botany, Chemistry, Chemical Engineering, Civil Engineering, Computer Technology, Electrical Engineering, Electronics and Radio, Geology, Guided Missiles, Mathematics, Mechanical Engineering, Medicine, Metallurgy, Meteorology, Mineralogy, Navigation, Nuclear Science and Engineering, Photography, Physics, Statistics, Zoology, and such related subjects as Astrophysics, Biochemistry, Biophysics, Nautical Astronomy, &c. Bearing in mind the large nomenclature possessed by every one of these subjects, the editors have had to exercise much selection in order to keep within the confines of one volume; this has been skilfully done. The text is supported by over 1400 illustrations. The book will provide a valuable aid to all those who require rapid access to facts, or the explanation of technical terms dealing with any branch of science or technology.

**Problemes D'Asservissements avec Solutions.** By P. DECAULNE, J. C. GILLE, and M. PELEGRIN. Dunod, Editeur, 92, rue Bonaparte, Paris (6e). Price Fr.2,400.

IT is a fundamental principle of teaching that complete assimilation of new concepts cannot be obtained without active participation by the student. The authors of the recently-published *Theorie et Technique des Asservissements* have recognised this fact in supplementing their servo text book by this latest work. The book is written to give the student the opportunity of solidifying ideas which, in some cases, may be somewhat abstract, and to provide teachers with suitable practical illustrations of the theoretical work covered in their first volume, thus offering a complete servo course. It is also intended that the professional servo engineer would find useful information and possibly fresh lines of approach to his particular problems.

The layout of the book is similar to that of the parent work so that both can be used in parallel to advantage, firmly establishing each new topic before proceeding to the next. Each chapter contains several problems worked out in full detail and they are followed by further problems designed for solution by the student. Lines of attack are sometimes indicated but the answers are not always given and this may be a drawback in the case of the student who is working independently and has no other means of assessing his progress. The worked problems are taken from a wide variety of branches of engineering to which the servo principle has been applied and, in most cases, the particular difficulties associated with each subject have been well illustrated.

The use of the Laplace Transform and the various graphical methods of assessing stability are particularly well covered and a large number of examples of stability compensation are given. Most of the non-linearities which occur frequently in practice are included in the appropriate chapter and the methods shown should be useful to the practising engineer who is very often reduced to trial and error when confronted with significant non-linearities. The analogy between electrical and mechanical systems is fully exploited and it is felt that this should be of great assistance to the servo engineer who feels much more at home in one of these fields but must utilise elements in the unfamiliar group. The publication of this book enhances the value of the original work considerably and the two volumes are strongly recommended to novices in servo work as a comprehensive course and to practising engineers as a refresher and reference.

## Books Received

*Siemens Brothers, 1858–1958.* By J. D. Scott. Weidenfeld and Nicolson, 7, Cork Street, London, W.1. Price 35s.

*Hohere Technische Mechanik.* By Istvan Szabo. Springer-Verlag, Reichpietschufer 20, Berlin, W.35. Price DM.31.50.

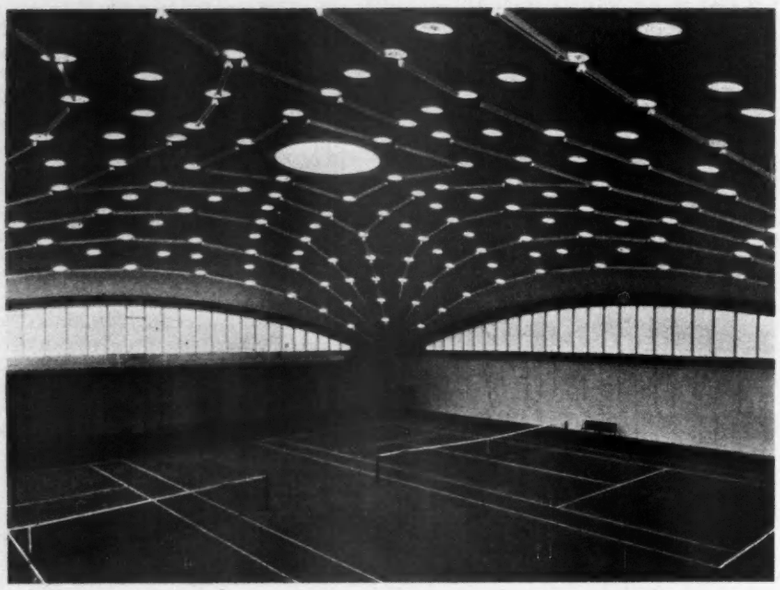
*British Coal Mining Explosives.* By J. Taylor and P. F. Gay. George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 27s. 6d.

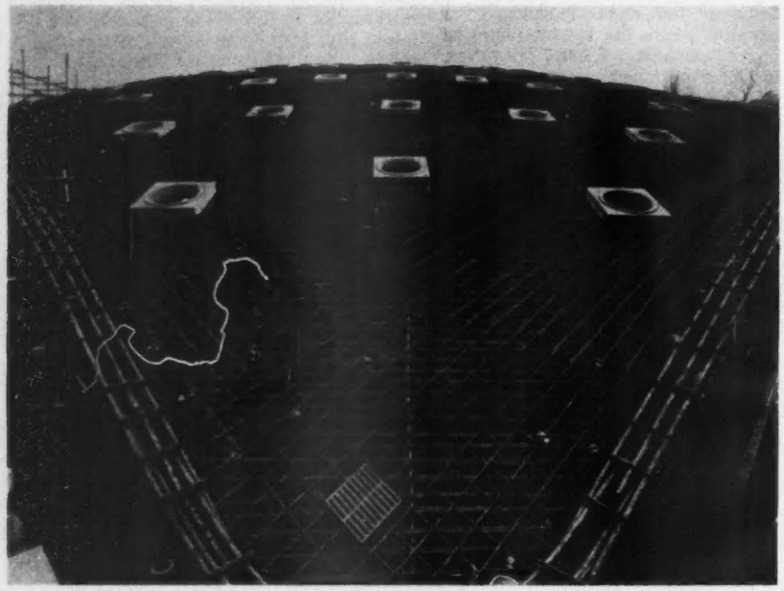
*Modern Apprenticeship.* By Dr. A. G. Beverstock. Classic Publications, Ltd., Recorder House, Stoke Newington Church Street, London, N.16. Price 10s. 6d.

*The History and Development of Light Cars.* By C. F. Caunter. Science Museum, South Kensington, London, S.W.7, or H.M. Stationery Office. Price 8s. 6d.

# Covered Tennis Courts

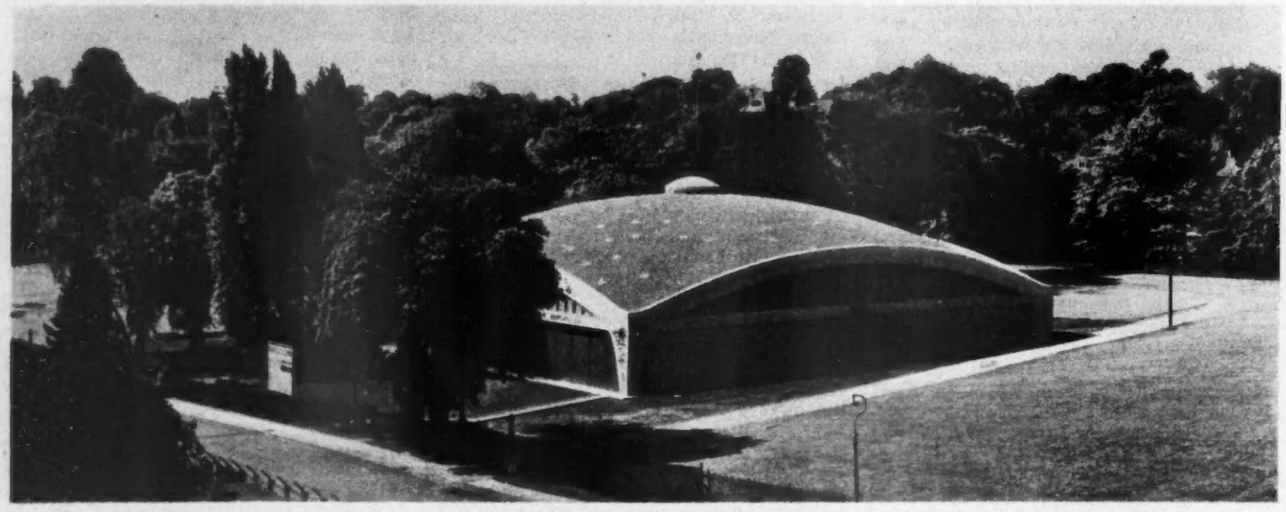
The two covered hard courts which have just been completed at Worple Road, Wimbledon, for the All England Lawn Tennis and Croquet Club, are intended as practice and coaching courts. Before building the present structure, three possibilities were investigated : (1) steel roof trusses and framework ; (2) twin cylindrical concrete shells ; (3) a doubly-curved concrete shell. The third scheme was chosen on the basis of cost, architectural and functional merits. The 3in thick shell forms a paraboloid with a span of 175ft, and a rise of 24ft 4½in. Four segments with a secant of 124ft 3in were cut off the circular projection, giving a square covering 15,200 square feet. Since the curvature of the shell is quite small, the "generating" scaffold tubes of the centering were bent to only three different radii, and the varying curvature was obtained by "springing" the tubes during fixing. Expanded metal permanent shuttering was used and can be seen in the background of the second illustration. Natural lighting is by glazed segmental openings on the four sides, 200 small roof lights set along the minimum principal stress trajectories, and a large central lantern. Fluorescent lamps fixed along the maximum principal stress trajectories give artificial lighting with an intensity of 40 lumens per square foot.





Design was based on the assumption that the shell is a stressed membrane, and its supporting arches resist forces acting only in their own planes. The Gifford-Udall prestressing system, adapted to high concentration of cables, has been used in the tie-beams. Plastic yield, shrinkage and differential settlement may seriously affect the stress distribution in a structure of this magnitude. The practical way of overcoming these difficulties was to render the boundary members statically determinate during prestressing, which in this case corresponds with the transfer of dead weight from the formwork to the four corner columns. This condition was achieved by using three "roller" bearings, consisting of a compression member hinged at the top and bottom by two similar throats, and one fixed bearing with one throat only. Since the throats are circular in plan, the hinges are similar to spherical metallic bearings. The initial condition of the "dome" can therefore be roughly compared with a table with three legs resting on three spheres, free to move in every direction, and the fourth leg fixed to a spherical bearing. After prestessing, all columns were then fixed by sealing the bottom throats.

The consulting engineers were C. J. Pell and Partners ; the main contractors W. H. Gaze and Sons, Ltd. in conjunction with Formcrete, Ltd.



# Display of Civil Engineering Developments

*The annual conversazione of the Institution of Civil Engineers was held in the Institution building at Great George Street, Westminster, last week on Thursday, June 26. The conversazione included, as customarily, a display of models and other exhibits showing recent work carried out by members. From amongst the twenty-seven exhibits which were to be seen we have selected one or two for description here.*

THE art of the structural engineer was well represented at the display of models which was to be seen in the library of the Institution of Civil Engineers last week, when the annual conversazione was held. From amongst those models concerned primarily with structural engineering, two may be mentioned here. One of them represented a project for a bridge across the River Tigris at Kut al Amara, Iraq, to carry the new Basra-Baghdad trunk road ; it was exhibited by Sir Bruce White, Wolfe-Barry and Partners.

The bridge is to have two balanced cantilevers with a central suspended span, constructed in high-tensile steel. The main span will be 135m, of which 56m will be covered by the suspended span and 96m by each anchor span. Anchor and cantilever spans are to be of single box form and the suspended span will have separate lower flanges and will be torsion free. The bridge will carry a single 8m carriageway and two 3m reinforced concrete footwalks, cantilevered from the main girders. The design live load is equivalent to British Standard HAI class loading. The main girders are to be 8m deep over the main piers and 3·26m deep at mid-span. The floor of the carriageway is to be of stiffened steel plate construction and will also act as the flange of the top main girder. The carriageway and footwalks are to be surfaced with rolled gravel asphalt. Considerable economy has been achieved in the design, the weight of structural steel being 6¼ metric tons per metre run. The main foundations are to consist of piers supported on groups of 4ft diameter piles planted in the alluvial deposits and carried down to an average depth of 90ft below bed level.

### Composite Steel and Concrete Construction

A great deal of interest has been shown recently in correspondence published in this journal, in composite construction in structural steel and reinforced concrete. It is therefore worth pointing out that a comprehensive investigation into one form of such composite construction is being carried out at Imperial College, with assistance from the British Constructional Steelwork Association. This work was illustrated at the conversazione by an exhibit due to Professor S. R. Sparkes, and Messrs. Chapman and Cassell.

In the design of a steel-framed building, it was pointed out, the cladding and floor slabs are not normally considered as contributing to the strength of the frame, but if the effect of cladding is taken into account economies in steel can result. The investigation in progress includes full-scale experiments on buildings, laboratory tests on full-scale components, and small model experiments. About a hundred vibrating wire strain gauges, and some other instruments, have been installed in the new mechanical engineering building, which is at present under construction at Imperial College. The building is of unusual design, having castellated beams acting compositely with the concrete floor slab ; composite action is ensured by studs which are welded to the top flanges of the beams. It is intended to measure strains due to erection, due to the dead weight of the structure, and due to superimposed loading during erection and during the life of the building. Some of the strain gauge installations, the arrangements for applying live load to floor slabs, and the relative weights of steel needed to carry a certain loading with different forms of composite construction, were explained.

### Road Construction and a Parking Garage in London

Models of two constructional schemes for road junctions in London were exhibited by the Ministry of Transport and Civil Aviation. In principle, they both involved grouping existing minor roads into a roundabout junction, taking the main route across the roundabout at a different level, and giving access to this main route by slip roads.

At the Chiswick flyover, now being built to link the Cromwell Road extension with the Great West Road and carry it over the North Circular Road, the flyover road will be about half-a-mile in length and will have dual two-lane carriageways. Slip roads will join the flyover to a 400ft diameter roundabout underneath. The flyover bridges will incorporate prestressed precast concrete beams and will have an in-situ concrete deck. Other sections of the flyover where it is not spanning public roads will be formed on embankments retained by concrete walls with brick facing. The area in which the flyover is being constructed is densely built up, but the demolition of buildings has been kept to a minimum, it is claimed, consistent with engineering requirements. The new works, which are estimated to cost over £800,000, have been designed by the Ministry's consulting engineer, Mr. Harry Brompton, M.I.C.E.

The proposed " Ace of Spades " underpass at the junction of the Kingston By-pass (on the London-Portsmouth Trunk Road A.3) and the Surbiton-Leatherhead Road A.243 will allow through traffic on the Kingston By-pass to flow under the junction. There will be four one-way slip roads for turning traffic, and special facilities for pedestrians to cross the underpass. In addition to the underpass, it is now proposed as part of the same improvement to build dual carriageways to join with the existing short length of dual carriageways at Woodstock Lane about 1000 yards on the Esher side of the junction. The complete scheme, which will cost about £500,000, has been designed by Mr. D. S. Samuel, M.I.C.E., the Surrey county engineer. Work is already in progress on alterations to services affected by the scheme.

The multi-storey ramped garage now under construction for Selfridges, Ltd., is a reinforced concrete structure with a basement for the reception and despatch of store merchandise, a ground floor selling area, and seven parking floors above. Parking floors are connected by 1 : 10 ramps taking two-way traffic, and there are passenger lifts to all floors. The garage, which has a capacity for 1000 cars, will be the largest of its kind in London.

The main store, which is steel-framed, has been extended over to meet the garage structure. The ground floor extension runs right through the garage structure, allowing customers to reach their cars by lift from the store itself. Ramps in tunnel connect the basement with the streets and freight lift service to the main store allows all reception and despatch of merchandise to be handled under cover. The structure is founded on some 1800 in-situ piles, driven into London blue clay. Design loading on the piles is 60 tons and maximum column loading is 1600 tons. The work was started in January, 1957, and is due for completion in May, 1959. The consulting engineers are Messrs. John Liversedge and Associates and the main contractor is Gee, Walker and Slater, Ltd.

### Non-Linear Suspension Problems

A recent study of the problem of low-frequency vibration isolation carried out at the engineering laboratory of the University of Cambridge has shown that in certain applications non-linear spring systems are preferable to the customary linear springs. This study was one of several researches exhibited by Professor J. F. Baker. In modern aircraft low-frequency isolation demands spring systems which ensure a natural frequency of the suspended equipment which is of the order of 1-2 c/s. Such low natural frequencies can be produced only with very soft springs which, if linear, exert hardly any locating function under steady state accelerations of the aircraft frame or under shock excitation, such as during landing conditions. This difficulty can be overcome by the application of non-linear isolators which have a soft spring characteristic only in the vicinity of the " working point," that is, after having taken up the static weight of the supported equipment, but which become progressively stiff when deflected therefrom.

The application of non-linear vibrations isolators may give rise to instability phenomena, a problem illustrated by the first exhibit which represented a symmetrical mass suspended on four non-linear springs. The system showed that under certain conditions the vertical parallel motion of the mass may become coupled to a rocking motion in the vertical plane or a similar motion in the horizontal plane. These coupling effects are irreversible.

It has been found convenient to investigate these coupling phenomena with the aid of a mechanical analogue known as the " Pen-Tor Analogue I," which was also demonstrated. It consisted of an ordinary pendulum which incorporates, at its lower end, a torsional system. The motion of the pendulum represented the parallel vertical motion of the mass of the first exhibit, and the motion of the rotor corresponded to one of the rocking motions of that system. The analogue demonstrated that under certain conditions the vertical motion may become coupled to one of the rocking motions and that this coupling is non-symmetrical.

The theory of non-linear systems with two degrees of freedom is also being studied and a model representing such a system was exhibited. Theoretical analysis has shown that in the non-linear case the " normal modes " of vibration of the system may

become coupled. The nature of this coupling depends on the system characteristics.

### Jacking a Mine Winder Tower

Advances in mining techniques at the National Coal Board's collieries were shown on three models of recent friction winder towers, which were exhibited by Mr. C. A. C. Davies, chief civil engineer of the National Coal Board. One of these towers, Woolstanton No. 3 tower, in North Staffordshire, is built rather close to old mine workings, and it has been designed with a structural jacking system which will be used to bring the tower back to verticality if subsidence occurs. Construction of this tower is now well advanced.

The tower is carried on four reinforced concrete columns which terminate in cylindrical feet at the jacking level. The jacking assembly in each of the four cylinders will lift a weight of 2000 tons. The cylinder is 14ft 6in in diameter, and at the centre there is a key, 8ft 6in in diameter and 12in long, in the upper part, which fits in a corresponding recess in the lower part, thus " locating " the column. In the annular space around the key six 24in " Freyssi " flat jacks are placed, alternately with six steel wedge assemblies. These assemblies each comprise steel plates attached to the upper and lower sections of the cylinder, with fixed and movable wedge elements, the latter being constrained by side cheeks. The friction of the wedges is to take up the movement imparted by the flat jacks, so that reliance is not placed on the hydraulic system to hold the column in position as jacking progresses. By driving in the wedge of each assembly to its full extent a lift of $\frac{1}{2}$in is obtained. By inserting one or two shims, each $\frac{1}{16}$in, a maximum lift of $1\frac{1}{2}$in can be obtained. The design figure taken for maximum settlement was 1in, but there would appear in principle to be no insuperable difficulty in applying this procedure for greater lifts.

The jacking system has been designed by the engineering staff of the National Coal Board in conjunction with the consulting engineers for the tower, Messrs. C. H. Dobbie and Partners.

### Electric Drum Winders

The three friction winder towers referred to above are examples of the National Coal Board's recent multi-rope designs. Generally, four ropes are used. Rufford No. 3 tower, which has been in operation about 18 months, is an installation of 3423 h.p., which can wind 450 tons of coal per hour from a depth of 3100ft. Kellingley Colliery No. 1 tower is just starting operation ; it has two winders each of 1100 h.p., with a capacity of 280 tons per hour from a depth of 2400ft. Kellingley is a new colliery, and the first duty of the winding engines is for shaft sinking. Woolstanton No. 3 tower, the jacking system for which we have just described, will have two winders, each of 3300 h.p. Two hundred tons of coal per hour will be wound from a maximum depth of 3900ft, with insets at several depths from 1850ft.

With one or two small exceptions all the electric winding engines installed in this country prior to 1946 were of the drum type, the drums being either parallel conical or bi-cylindro-conical. Where permanent arrangements had to be made for winding from more than one seam a winder with two drums, one clutched and one free, was used to obviate " shuttle " winding. The most serious disadvantage of the clutched drum winder is that a balance rope cannot be used and there is the heavy starting peak inseparable from unbalanced winding which often necessitates a larger motor than would otherwise be required. There is also an appreciable amount of time lost in adjusting the active rope length to suit the various levels, and the brake and clutch interlocks are rather complicated.

The end of the last war saw the establishment of the Coal Control Commission in the Ruhr and this, together with the publication of the reports of the British Intelligence Objectives Sub-Committee, led to a closer study of Continental mining practice. Winding was one of the subjects to which attention was particularly directed and there quickly developed a keen interest in friction winders which, although first developed by Koepe in 1877 and almost universally adopted on the Continent, received scant attention in Britain apart from the small but interesting tower winder installed at Murton Colliery in 1922 and several very small winders at other collieries in the Northern Coalfields. This newly-awakened interest in friction winders coincided with the nationalisation of the mines and major reorganisation of the collieries ; electrification of the winding equipment was in the forefront of most of the reorganisation schemes. Many of these schemes involved working the lower seams and in order to obtain an economic output, payloads of 12 to 15 tons were envisaged. The conditions demanded winding ropes of larger diameter and greater length than had hitherto been necessary and these, in turn, called for winding drums of increased size. In many cases it was found that even if the drum diameter were increased to 20ft the whole of the rope could not be accommodated on the drum unless its width was increased to a value which would result in an unsatisfactory angle of fleet. Satisfactory coiling of the rope on the drum is only possible if the fleet angle does not exceed about 1 in 30, and in the case of a 3000ft shaft, where the load demanded a winding rope of $2\frac{1}{4}$in diameter, these conditions could seldom be fulfilled without resorting to multi-layer coiling. Although multi-layer coiling is in use at some collieries in Britain and is widely used in South Africa, engineers in this country have always been reluctant to adopt it and it was generally felt that to employ it for very large locked coil ropes would be unsatisfactory. These several problems prompted closer investigation into the suitability of the friction winder for meeting the changed conditions.

Single-rope friction winders, which may be either ground-or tower-mounted, have a narrow driving pulley which has only a fraction of the weight and inertia of the equivalent parallel drum. The power consumption per trip for a given set of conditions will therefore be less. The drive is effected by the friction between the rope and the tread of the friction pulley and the latter is therefore lined with a material having a high coefficient of friction in order that there shall be no rope slip. A balance rope is essential and either one large rope or two small ropes may be used for this purpose. A large round rope possesses a considerable amount of twist and, even when connected to the conveyance by a swivel, may produce sufficient torque to displace the conveyance in mid-shaft if rope guides are used. The most important single factor governing the payload which can be lifted from the deeper seams is the maximum size of winding rope which can be constructed to work satisfactorily and have an economic life. It would appear that a locked coil rope of about $2\frac{1}{4}$in diameter is the largest that will fulfil these conditions and it became necessary to consider other alternatives. It will be clear, therefore, from what has been said above that the single-rope friction winder still has the disadvantage of using a very large rope and unless a cage and counterweight system is adopted, for which an even larger rope is required, it does not get away from the disadvantages of the clutched drum.

For these reasons the question of using multi-ropes, as in normal lift practice, was carefully studied by British engineers and finally adopted where economically justified.

Where winding has to be carried out from several levels the cage and counterweight system possesses many advantages and provides a great measure of flexibility. The winding cycle to a given level requires two trips and two decking intervals so that the payload must be doubled for a given output, and this calls for a correspondingly large cage or skip, the use of which is made possible only by the introduction of multi-ropes. Despite the necessity for doubling the payload, the net out-of-balance load can be maintained at a figure corresponding to that in a double cage system by choosing a suitable counterweight, which is usually made equal to the weight of the conveyance plus half the payload.

## The Rajasthan Canal

Work on the Rajasthan Canal, claimed to be the longest in the world, began on March 28, when Mr. Pant, the Home Minister, inaugurated the construction of India's most ambitious irrigation project, designed to utilise the Bhakra-Nangal waters for irrigating over 2,600,000 acres of Rajasthan desert, along the Indo-Pakistan border. The canal, about 425 miles long, is estimated to cost Rs.66 crores,* of which a third will be spent during the Second Plan period. The irrigated areas are expected to yield nearly 1,000,000 tons of additional food grains and cash crops valued at nearly Rs.30 crores. The canal will take about twelve years to complete. The Rajasthan canal itself will consist of two parts. The head reach, or Rajasthan feeder (110 miles), will take off from the Harike barrage across the Sutlej, about 2 miles below its confluence with the Beas, near Ferozepore in Punjab State. The lower reach or Rajasthan canal will be 315 miles long and will lie entirely within the territory of Rajasthan. The scheme will be executed jointly by the Rajasthan and the Punjab Governments. About Rs.30 to Rs.50 crores will be spent on the headworks, some of which have been already taken in hand and will be completed ahead of the canal proper.

Details about the canal dimensions are not yet available, but it is stated that its maximum capacity will be about 18,000 cusecs. The Minister of Irrigation and Power told the Parliament last August that at some additional cost some portions of the canal will be made navigable. The Rajasthan canal network will be linked with the Bhakra-Nangal system through storage dams on the Beas and the Ravi. All the water will be made available to the Rajasthan State and there will be no take-offs before the canal reaches the state boundary.

The three rivers which will be more or less fully utilised, namely, Ravi, Beas and the Sutlej, are the eastern rivers of the Indus system of rivers, whose entire flow has been allocated by the World Bank (which acts as an intermediary in the Indo-Pakistan dispute over the use of these waters) to India, the flow of the three western rivers being allocated to Pakistan. India has accepted the Bank proposals, but its decision to go ahead with the construction of the Rajasthan canal was taken despite the Pakistani protests that the canal would deprive Pakistan of what she considers her share of the eastern rivers of the Indus system. India's decision was largely influenced by the recent spate of famines throughout the country and the consequent drain on her valuable foreign exchange reserves.

* Rs.1 crore = £750,000.

# Chemical and Petroleum Exhibition

No. III—(*Concluded from page 980, June 27*)

*The Chemical and Petroleum Engineering Exhibition closed on Saturday, June 28. We conclude here our description of some of the exhibits which were representative of the plant and equipment, both large and small, designed and manufactured for the petroleum and chemical industries.*

### Hayward Tyler and Co., Ltd.

A SELECTION of the pumps manufactured by Hayward Tyler and Co., Ltd., was shown. There were two chemical pumps, a sectioned vertical two-stage cargo pump, and another unit having a capacity of 690 gallons per minute at 390 deg. Fah. with a differential head of 120ft and driven by a 40 h.p. motor. A fire pump was also shown; it is of single-stage centrifugal design having a capacity of 500 to 800 gallons per minute and a differential pressure range of 50 lb to 150 lb per square inch at control. The impeller speed is 3600 to 4000 r.p.m. and the drive shaft speed 1500 to 2300 r.p.m. A Hayward Tyler-Byron Jackson turbine-driven horizontal 1½in by 2in by 10in process pump was on the stand; it is designed to handle hot or cold liquids with a low net positive suction head. The impellers have large eyes and passages giving low velocities and maximum freedom from cavitation. The drive for the pump is a Hayward Tyler-Terry back pressure steam turbine which is basically a single wheel, having a maximum speed of 4500 r.p.m., where jets direct steam into the wheel buckets.

### Rolls-Royce, Ltd.

The various prime movers shown by the Oil Engine Division of Rolls-Royce, Ltd., Sentinel Works, Shrewsbury, not only illustrated the range of engines available but emphasised the degree of rationalisation achieved in their production. This rationalised range includes normally aspirated, supercharged and turbo-charged vertical, horizontal or marine units having four, six or eight cylinders and covering horsepowers ranging from 60 to 600 b.h.p. The engines are of four stroke, direct injection compression ignition design, having a bore of 5⅛in and a stroke of 6in and a compression ratio when normally aspirated of 16 to 1 and 14 to 1 when supercharged or turbo-charged. On view was a mark C.8N.F.C. twin eight-cylinder power pack driving a torque converter through a 1·52 to 1 reduction gear. At 1800 engine revolutions per minute the pack develops a maximum heavy duty rating of 362 b.h.p., a maximum continuous rating of 416 b.h.p. and has an intermittent rating of 465 b.h.p. Also on view was the mark C.6N.F.R. unit, developing 124 b.h.p. at 1550 r.p.m., which is the power unit of the International Harvester B.T.D.20 crawler tractor.

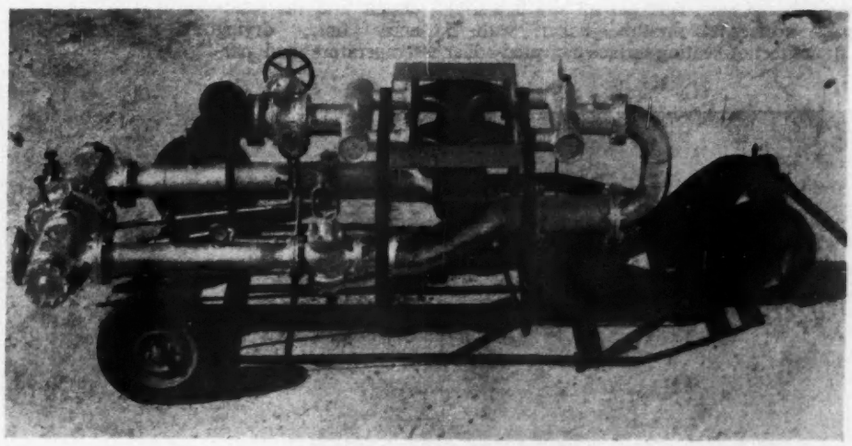
### Davey, Paxman and Co., Ltd., and the Oil Well Engineering Company, Ltd.

These firms, besides showing individual products, used the combined stand to display a full-size "Oweco" drilling rig powered by three Paxman 400 "Drilpack" engines. The drilling rig supplied by the Oil Well Engineering Company, Ltd., Cheadle Heath, Stockport, Cheshire, includes a "G.700" slush pump having cylinders of 8in bore by 14in stroke, a maximum discharge pressure of 1265 lb per square inch and an output of 805 gallons per minute at seventy strokes per minute. The "80B" consolidated rig is rated at 800 h.p. and designed for medium depth drilling, its major applications being in the 6500ft to 10,000ft depth range. It has a hoisting drum of 25in diameter by 49in long, able to handle 90ft stands of drill pipe without spooling more than three layers of line, and a coving reel drum of 14in diameter by 43in long with capacity for 10,000ft of ⅝in wire. The power units for the rig, built by Davey, Paxman and Co., Ltd., Colchester, are three packaged mark 12 R.P.H. engines, each developing 400 h.p. at 1200 r.p.m. and having a bore and stroke of 7in by 7¾in.

### Elliott Brothers (London), Ltd., and Fisher Governor Company, Ltd.

A wide range of equipment for the instrumentation and automatic control of processes was shown on the stand of the Elliott-Automation Group. The display included the Fisher "Wizard 2" pressure controller which is a development of the original pressure pilot and has been introduced to include additional items to improve the degree of accuracy with which fluid pressures can be controlled. The unit is essentially a pneumatic pilot which is used, in conjunction with a diaphragm control valve, to convert deviation in control pressure in any fluid into an air pressure capable of repositioning the control valve to restore the fluid pressure to the desired value. A bourdon tube suitable for pressures from 10,000 lb down to 5 lb per square inch forms the measuring element, and by a flapper and nozzle arrangement controlling a variable orifice, to which compressed air is supplied, an air pressure is developed which is proportional to the change in controlled pressure. The air pressure is amplified by relay which provides diaphragm loading air capacity with linearity of output.

The blending unit, as illustrated, has been developed for in-line blending of intermediate grades of fuel oil. It operates on a volumetric proportioning device by maintaining the same differential pressure across two orifices so that variation in volumetric ratio is attained by changing the orifice area ratio. The unit is self-acting and fuel oils having viscosities up to 4000 seconds Redwood No. 1, at pumping temperatures, can be handled.



**Fuel oil blending unit**

### Q.V.F., Ltd.

At each corner of the stand of Q.V.F., Ltd., was placed a reaction unit suitable for attachment to glass-lined vessels. One of them was a simple, straight distillation unit for either atmospheric or vacuum distillation and the assembly can condense 800 lb per hour of N-butanol. The second unit was a general purpose overhead arrangement for carrying out reactions under reflux followed by straight distillation, such as solvent removal and can handle 800 lb per hour of a liquid boiling at 175 deg. Fah. with latent heat of 170 B.Th.U. per pound. There was also an exhibit developed for process conditions which give rise to high boil-up rates or to high content of incondensable gases and is suitable for use where reactions are exothermic and there is a possibility of sudden and uncontrollable condensing loads on the heat exchangers. This assembly can reflux or distil 350 lb per hour of water. The other unit was a simple equipment for carrying out reaction under reflux followed by straight distillation. Three examples of vibro-mixers were on view, the equipment consisting of a vibration generator operating on alternating current, which vibrates the shaft, to the base of which a circular perforated plate is attached. By means of a two-way switch, the length of the vertical stroke of the shaft can be altered to give either increased or decreased mixing action. In the centre of the stand was a condensing tower 18in in diameter by 30ft in height which can be used for any acid and which incorporates divisions formed by glass bars capable of taking a load of 600 lb.

### Baker Perkins, Ltd.

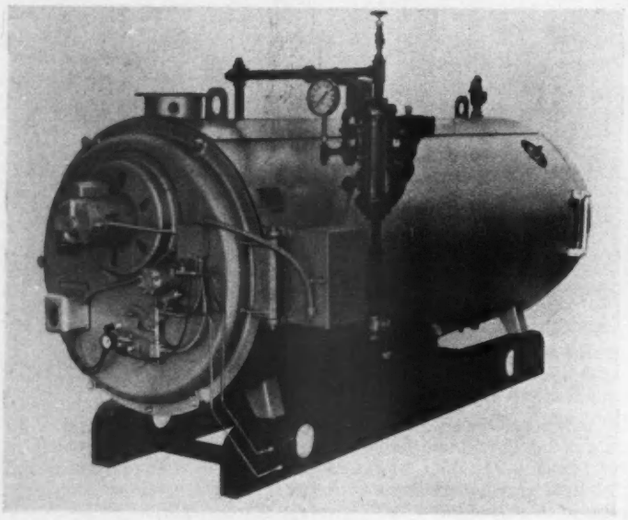
A variety of mixing machines, extruders and ancillary machinery for the plastics and rubber industries were exhibited by Baker Perkins, Ltd., Westwood Works, Peterborough. For the rubber industry there was on view a heavy duty rubber mixer/masticator which has a capacity of 54 gallons and is powered by a 200 h.p. Laurence Scott electric motor. The drive is through David Brown gears to the front blade which is geared to the rear blade, the speeds of the blades being, respectively, 36·6 r.p.m. and 24·8 r.p.m. Cast mild steel is used for the three

wing blades which are cored to allow for water cooling. Air at 100 lb per square inch enables the ram to exert a pressure of 4 tons, while water at a similar pressure is used for hydraulic equipment for tilting the mixing chamber to discharge the mix.

Another example of the company's products is a "Flowmaster Reactor" which is a continuous heat exchanger mixer for the blending of pumpable mediums and designed so that heat can be transferred to or from the material being processed. The unit consists of fixed heat transfer plates, through which the heat transfer fluid can be circulated, separated by beaters having four arms mounted on a common shaft. The material flows through holes in the stator heat transfer plates and beater sections to give intensive mixing and in addition the turbulence creates a thin film which gives high heat transfer coefficients. The maximum working pressure is 350 lb per square inch gauge and the operating temperature range 32 deg. to 400 deg. Fah., while the heat transfer plate operating pressure is 100 lb per square inch gauge steam. Three sizes of reactor are available, having plate diameters of 7in, 11in and 18in, and corresponding throughputs of 20, 200 and 750 gallons per hour.

### Marshall Sons and Co., Ltd.

In addition to a Fowler "Challenger" diesel crawler tractor equipped with a Marshall side boom crane, a road roller and other forms of tractor, there was a "Monitor 30" Cleaver-Brooks fire-tube packaged boiler shown by Marshall Sons and Co., Ltd. Britannia Works, Gainsborough. The boiler has an evaporation rate of 1035 lb per hour and is one of a range having ratings from 500 lb to 2000 lb per hour. It is designed to burn light gas oil and is a four pass horizontal fire-tube boiler, with 5 square feet of heating surface per rated boiler horsepower, mounted on a steel frame with integral forced draught blower and burner controls. The shell is constructed for 150 lb per square inch and the hinged front and rear heads are completely sealed with heavy duty cap screws. Rear refractory and insulation are contained in the rear head and the boiler is insulated with a glass fibre blanket. Oil burners of the pressure atomising multi-nozzle pattern with automatic two-stage ignition are fitted and operated on the on-off principle.



"Monitor 30" fire-tube packaged boiler

### Air Pumps, Ltd.

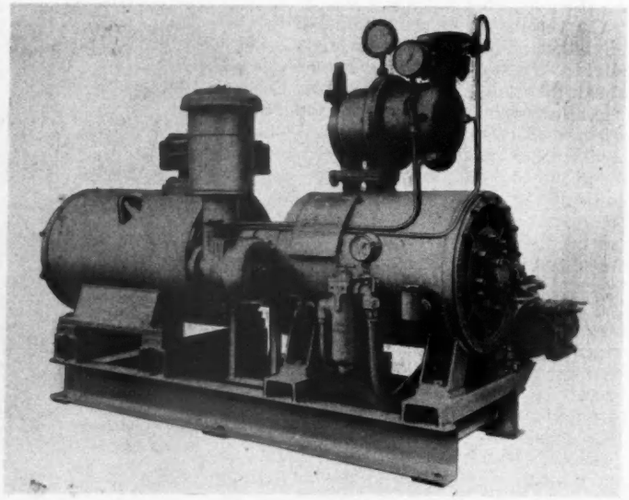
Air Pumps, Ltd., Bushey Road, London, S.W.20, included among its exhibits a stationary and a mobile compressor. The former was a model ARSM 525 unit consisting of a two-stage air cooled rotary sliding vane air compressor capable of delivering 525 cubic feet per minute of free air at 100 lb per square inch gauge. A high torque squirrel cage, screen protected, 50 c/s three-phase electric motor drives the compressor at 1480 r.p.m. The air receivers have a capacity of 14 cubic feet and the heat generated during the compression cycle is transferred to the oil cooling medium so that the internal temperature is kept low. The oil is passed through an air cooler and the cooled compressor oil is pumped at high pressure to the bearings, so that the oil lubricates, cools and seals. All components are mounted on a rigidly welded frame. The mark ARMD 625 mobile unit is fitted with a similar compressor which is driven by a Dorman 6L.C.T. diesel engine, and at a governed r.p.m. of 1700 delivers 600 cubic feet per minute of free air at 100 lb per square inch gauge. The mobile unit is fitted with a mechanical control which shuts down the set should the engine overheat, and both compressors have mechanical shut down devices providing for high compressor oil/air temperature or low compressor air delivery pressure.

### F. W. Berk and Co., Ltd.

The industrial dryer division of F. W. Berk and Co., Ltd., Berk House, Portman Square, London, W.1, showed a ring dryer which is a pneumatic dryer in which the product is held airborne in a closed circuit and the residence time, drying temperature and particle size can be controlled. In the ring jet spray dryers, of which 12in and 4in diameter disc sizes were shown, the spray is produced by a combination of centrifugal force and blast, and the unit consists of an electric motor built integral with a disc; the hollow shaft of the motor houses a feed tube and the assembly is mounted within a casing to which air is supplied under pressure. The disc speed is 3000 r.p.m. so that only standard ball bearings are required. The liquid to be dried is fed through the inner tube and the disc runs inside an air nozzle arranged so that the outlet is the space surrounding the periphery of the disc. Thus the liquid film from the rim of the disc is entrained by a ring jet of air and torn into droplets. The unit is arranged to project the spray downward into the drying chamber and the drying air flows downward in the centre and then upward over the surface of the cylindrical wall to be exhausted by cyclones which collect the dried product. Another exhibit was a fluid bed dryer which was shown as a pilot plant and is used for materials requiring long residence time as compared with that in a ring dryer. The material is fed from above into the bed which is kept in a "boiling" motion by hot air which is pushed upwards through the porous base of the bed. In its fluidised state the product to be dried finds its own level and flows from the bed over a weir in a central collector. Any airborne material is collected by cyclone and the air finally discharged.

### Worthington-Simpson, Ltd.

Chemical petroleum and power pumps representative of those manufactured by the company were on view on the stand of Worthington-Simpson, Ltd., Lowfield Works, Newark-on-Trent. There were two examples of vortex pumps, a single-stage and a two-stage, the former being rated at 15 gallons per minute against a head of 120 lb per square inch, inclusive of suction lift when driven at 2900 r.p.m. by an electric motor. The two-stage unit delivers against a head of 600ft. These are self-priming high head low capacity pumps and the exceptional power has been attained by adopting modern principles of regeneration . This involves the use of a multi-vaned turbine pattern impeller which engages and re-engages the liquid being pumped to create a vortex flow in the peripheral channel of the pump casing and convert a velocity head into a pressure head. The power pump shown has a bore and stroke of 4in by 6in and is a double-acting unit suitable for handling viscous liquids and is rated to deliver 74 gallons per minute at a maximum pressure of 250 lb per square inch. Additional to the pumps was a mark "OCR 200" two-stage oil cooled rotary air compressor (illustrated herewith), which has a displacement of 200 cubic feet per minute, a delivery pressure of 120 lb per square inch gauge and is driven by a 50 h.p. electric motor at 1450 r.p.m. Oil is used as a cooling medium, for lubrication and to form an effective seal against air leakage,



"OCR 200" two-stage oil-cooled rotary air compressor

the oil being cooled in a water cooled heat exchanger. The oil, acting as an internal coolant, results in the final air temperature being below 200 deg. Fah.

### Stockdale Engineering, Ltd.

The agitator drive shown by Stockdale Engineering, Ltd., London Road South, Poynton, Cheshire, was designed to cover the majority of top entering agitators. Four sizes of spiral bevel gearbox drive are in production, of which No. 3 was on view. Power is provided by an electric motor which drives through a flexible coupling the primary drive passing through the box the first reduction gearing, which is on the opposite side to the electric motor. First reduction consists of helical spur gears and the second shaft enters the box to drive the vertical agitator shaft through a spiral bevel and a crown wheel pinion. Removal of a cover plate permits the first reduction gearing to be replaced should a change of speed be required. An oversize output shaft is fitted and the bearings are widely spaced so as to take up the thrust and journal loads set up by long unsupported overhung shafts. A continuous pipeline mixer, the "Nettco Flomix," which the company manufactures under licence, was demonstrated. It is designed to be installed in a pipeline to mix liquids flowing through the line and achieves the mixing effect by dividing, reversing and combining the entering flow coupled with mechanical agitation. The liquids to be mixed first come in contact with a raked blade turbine agitator and are then forced through orifices into a second chamber where the fluid is again agitated by a propeller. Finally, the flow is reversed by the baffling of the outlet passage before leaving the mixer to continue along the pipeline. Also on the stand was a rotary vacuum filter, of pilot plant size, with string discharge and a horizontal rotary vacuum filter with discharge scroll.

### F. Perkins, Ltd.

Perkins diesel engines provided the power unit for several items of equipment at the exhibition, and on the company's own stand was a full range of industrial engines manufactured at Peterborough. There were models of "L," "P" and "R" engines and also examples of the latest engine, the 1·6-litre, "Four 99" unit. This engine has a bore and stroke of 3in and 3·5in respectively, a swept volume of 1·621 litres, and a compression ratio of 20 to 1. It has a twelve-hour rating of 32 b.h.p., an intermittent rating of 35 b.h.p. at 3000 r.p.m., and is a suitable power unit for many items of small industrial equipment. A rotary fuel pump is fitted and the engine has a new combustion system in which the upper part of the combustion chamber is hemispherical in shape and is machined into the cylinder head, while the lower part is formed by an inserted machined plug which contains the oval port connecting chamber to a cylinder. Fuel is injected by a pintle nozzle. During the compression stroke cylinder air passes vertically through the oval port to produce a swirl in the chamber and to move transversely across the nozzle. At the point of combustion the final part of the air is transferred violently from the head, through passages of special shape machined in the head and chamber insert, horizontally into the combustion chamber to set up considerable turbulence in the mixture of fuel and air already present and so promote complete combustion and utilise the maximum quantity of air.

### Wellington Tube Works, Ltd.

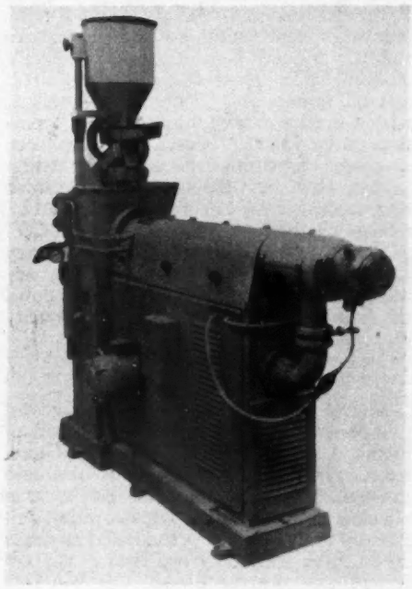
Emphasis on the stand of Wellington Tube Works, Ltd., Great Bridge, Tipton was placed on the company's air cooled heat exchangers and a four fin unit was on view. Although air has been used as an industrial coolant its use has been restricted generally to waterless sites, but scarcity of cooling water has resulted in a new economic appraisal of air cooling for static plant. The unit displayed is intended for service with a refinery or power plant and consists of rows of finned tubes arranged horizontally between headers to form standardised tube bundles. These rest on a welded tubular support structure which also carries the air plenum chambers, of which there are four, one for each fan. The bundles are made up of 1in O.D. steel tubes, about 12 gauge in thickness, with aluminium fins ½in high mechanically bonded to the tube in a spiral. Fabricated from boiler plate, the headers are built to a pressure vessel code. The fans are driven through a right-angled gearbox from a horizontal motor and arranged for dual speed so as to give maximum economy of power when the ambient temperature is below the design summer temperature. The air is delivered vertically upwards into the plenum chamber which distributes the air uniformly.

### Lincoln Electric Company, Ltd.

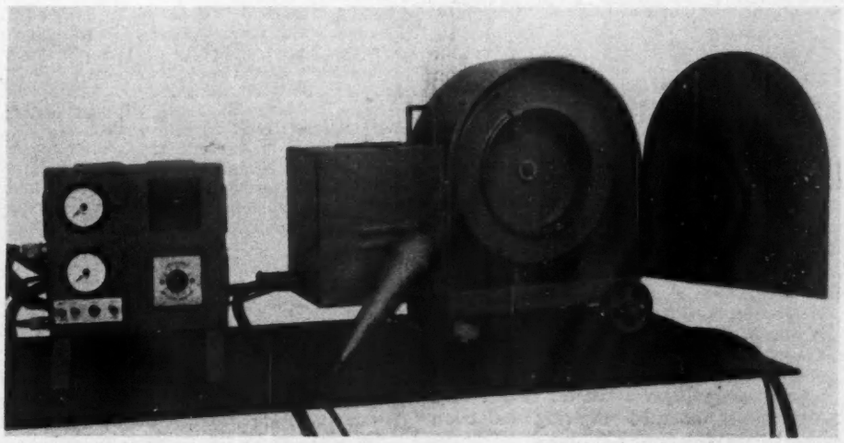
The Lincoln Electric Company, Ltd., Welwyn Garden City, Hertfordshire, gave demonstrations of "Stove Pipe" welding technique using "Fleetweld 5" and "Shield-Arc 85" electrodes, and also of the "Arcair" cutting and gouging process. The current for both demonstrations was supplied by a Lincoln SAE 300 motor generator. Also demonstrated was the B.10 fully automatic submerged arc welding head mounted on a travelling beam carried on a column. The equipment consists of the head and controls, electrode reel and mounting, flux feeder and straight wire contact assembly for butt welding. As shown, the work was arranged for rotation, while the beam carrying the head could traverse and also be raised and lowered. The latest extension to the company's d.c. motor generators the Lincoln-weld CV 750 constant voltage generator was shown and demonstrated the submerged arc automatic welding of pressure vessels. It is rated 750A at 40V for 100 per cent duty cycle, the voltage variation being from 18V to 42V. Another item was the ML2 manual submerged arc welder and the ML2 control unit, for use with the welder, which enables full control of the welding generator when the latter is situated away from the welding site. This equipment is of value when the work is in tanks since the operator need not return to the generator to correct settings. Our illustration shows an ML2 welder with remote control unit.

### Burtonwood Engineering Company, Ltd.

Machines for the plastics industry were exhibited by the Burtonwood Engineering Company, Ltd., Warrington. Included was a vertical 3½in Burtonwood-Cumberland "Dicer," for the production of cubed material from strip, and a Model O Burton-wood-Cumberland granulator, with an output of 125 lb per hour, for the granulation of scrap plastic material. A third machine was the 60mm Burtonwood-Andouart extruder, illustrated herewith, which has a 60mm diameter screw of high-tensile steel case hardened, ground and surface finished to fine limits. It is bored for water cooling and has a 20 to 1 length diameter ratio and is of constant pitch diminishing depth pattern. The solid forged mild steel barrel is precision bored and honed and the main barrel is provided with a hardened and ground liner honed to mirror finish. The barrel is arranged in four heating zones and



**60mm thermoplastic extruder**



**"ML2" semi-automatic welder with remote control unit**

machined to take hairpin pattern electrical heaters and deep-seated pockets for thermocouples. The hopper section is cored for water cooling and the internally polished feed opening is tangential and rectangular in form. A steep angle taper roller race takes the screw thrust and the double reduction gear consists of a double helical gear wheel and pinion and also a spur gear wheel and pinion. All gears and bearings are flood lubricated.

### Babcock and Wilcox, Ltd.

Exhibits on the stand of Babcock and Wilcox, Ltd., Babcock House, Euston Road, London, N.W.1, demonstrated the facilities at the Renfrew and Oldbury works for the fabrication and fusion welding of pressure vessels. Models illustrated the company's oil-fired boiler plant such as the "FH" integral furnace and "Steambloc" boilers, while a display showed the principle of operation of the "CO" boiler. This has been developed to utilise efficiently, for steam raising, both the sensible and combustible heat content of the exhaust gases from an oil refinery catalytic cracking unit. The "CO" gas ports are supplemented by oil and refinery gas burners for starting up and auxiliary firing, and should the catalytic be shut down the boiler can be operated at full capacity on supplementary fuels.

### Sigmund Pumps, Ltd.

Several examples of the many designs of pumps manufactured were on the stand of Sigmund Pumps, Ltd., Team Valley, Gateshead, 11. Particular emphasis was laid upon the rationalisation of the B-N units in which a range of mine pumps covering outputs up to 250 gallons per minute and heads up to 350ft using only two sizes of support frames and bearing houses. A WA-NE5 vertical glandless pump specially designed for installations in wet sumps for handling acids was on view, rated to deliver 225 gallons per minute against a head of 55ft. The hydraulic unit is submerged into the liquid to avoid priming difficulties. Also shown was a HO-NE5 high temperature process pump able to deliver 275 gallons per minute against a differential head of 280ft. It is a single-stage low-pressure unit having a high suction performance impeller and able to operate at temperatures up to 900 deg. Fah.

### Alley and MacLellan (Polmadie), Ltd.

A skid mounted Alley/Clark mark H.M.A. 6 gas engine driven compressor was exhibited by Alley and MacLellan (Polmadie), Ltd., Glasgow, S.2. The power unit consists of a six-cylinder engine of 8¼in bore by 8¼in stroke developing 265 b.h.p. at 600 r.p.m. and is directly connected to three double acting three-stage horizontal compressor cylinders. A typical application for such a unit, which is radiator cooled, is for gas lift service and it could handle about 1,500,000 cubic feet of natural gas per day from an initial suction pressure of 100 lb per square inch gauge to a discharge pressure of 1200 lb per square inch gauge. There was also an example of the Alley Series 56B range of horizontal balanced opposed piston compressors. This is a two-cycle single-stage unit having a capacity of 1000 cubic feet per minute at 100 lb per square inch gauge. The stroke is 6½in and the l.p. cylinder has a diameter of 17½in, the diameter of the h.p. cylinder being 10½in. Power is provided by a flange mounted slip-ring induction motor of 200 b.h.p. at 750 r.p.m.

# Torque-Converter Transporter

WE were recently afforded the opportunity to observe the operation of the prototype 50-ton quarry wagon used by the Lime Division of Imperial Chemical Industries, Ltd., in a limestone quarry at Tunstead, near Buxton, Derbyshire. The tractor was built by E.R.F., Ltd., to I.C.I. specifications and the semi-trailer was constructed by the Lime Division. This unusual vehicle has now completed a year's service: it was illustrated and briefly described on page 768, May 17, 1957.

It will be recalled that the vehicle is propelled by a 200 h.p. oil engine and twin disc torque converter of Rolls-Royce manufacture: the converter is a "CF" pattern (see page 249, March 9, 1956) with neither lock-up clutch nor dog-clutch, but the freewheel between turbine and impeller which allows the engine to be started by towing the vehicle has been omitted: this is because this vehicle, having great weight and rather low rolling resistance, would return considerable powers into the engine and converter, possibly resulting in failure of the freewheel. The "CO" converter has a freewheel adequate to provide engine and hydro-kinetic braking, and may eventually be incorporated (it was not in production in England when the vehicle was made): at present there is no engine braking available, which renders changes of ratio in the gearbox particularly easy, although they are normally unnecessary. In anticipation of this modification an exhaust brake has been installed: as a safeguard against malfunctioning of the hydraulic governor the fuel shut-off control has been slaved to the exhaust brake, and therefore independent controls for wheel and engine brakes are fitted. The converter has provision for collecting leakage through the seals—it normally runs at a pressure in excess of 50 lb per square inch—and a bleed of 1 pint in twenty-four hours' running is considered acceptable.

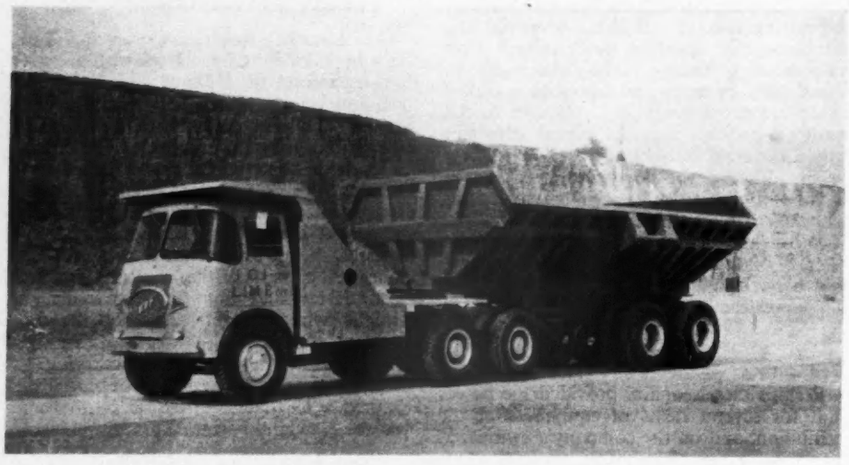
A very short propeller shaft connects the converter to the gearbox, a David Brown assembly which has been built up with only direct drive, overdrive, one reduction (1·82) and reverse trains. The drive then passes to the pinions of the two Kirkstall hypoid axles and out to the final reductions in the hubs. Only about one-quarter of the trailer weight is taken by the driving wheels.

The trailer is specialised, being built to charge the stone crusher at Tunstead. It has on the off side two outriggers from the chassis which run on to a rail beside the crusher: a hook located from the structure of the building then engages the bar visible in our illustration and lifts the near side of the body. As the load is tipped the weight is transferred, not to the off-side trailer wheels, but to the stationary rail.

The structure of the trailer is conventional, but it is interesting to note that the trailing bogie is basically that of the Kirkstall unit used on the Thornycroft "Mighty Antar." In order to allow wheels and axles common to the existing smaller vehicles to be retained, special casings were made at Buxton to couple these axles to the remaining elements of the "Antar" bogie. Brakes are fitted to the front axle only, it being found that those on rear axles are prone to damage by reversing into fragments of rock. A trestle pivoted below the chassis swings down to support the trailer when uncoupled.

From our description it will appear that the equipment is unusual in several respects. Large earthmoving plant usually has off-the-road capability whereas this tractor is modelled upon a conventional truck: a simple torque converter transmission is not expected to meet the performance and economy requirements of a normal wheeled vehicle: and no effort has been made to provide the maximum braking power. These facts are explained by the employment of the vehicle. The length of each journey is short, four or five minutes being spent actually under way in each work cycle, and the quarry is provided with concrete roads on which the vehicles run. This is found to be worth while because tyres are the largest item in the transport costs; in addition the site is laid out so that there is a favourable gradient of 1 in 100 for vehicles proceeding loaded to the crusher. The torque converter justifies itself, despite an increased fuel consumption, by faster trips, less driver effort—normally the transmission remains in direct drive when running loaded and overdrive when empty—and by a valuable reduction in unscheduled maintenance caused by gearbox failures: the increased loading imposed on the gears by the converter is less harmful than the shocks that can be injected by a plate clutch. Particularly interesting, in view of the operator's experience that tyres usually fail catastrophically rather than wear out, is the fact that the walking beam geometry and the use of adequately large tyres—on the trailer—have allowed the vehicle to complete a year's work on its original tyres and with only three punctures. Metallic tyres are used, and Michelin "X" will be used as replacements in view of the freedom from damage to the inner tube by strands of wire that has been experienced with this make.

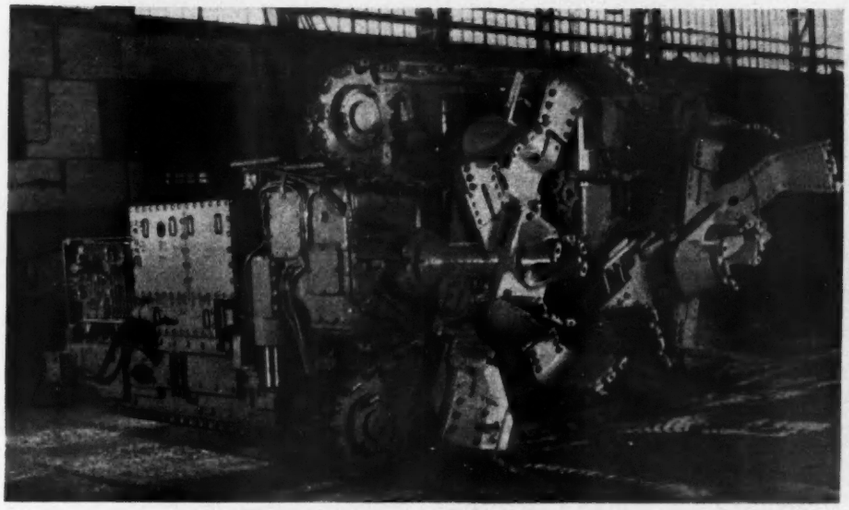
The quarry allows ample room for manœuvre, so that the long wheelbase of the tractor is no disadvantage; the equipment is usually reversed up to the loading excavator in almost a straight line. The technique of emptying is not without interest: the crusher house is so arranged that when the tipping hook is opposite the bar on the body, the driver's window is opposite the hook controls.



**The 50-ton limestone carrier seen in the Tunstead quarry**

# Continuous Mining Machine

FOLLOWING a visit to the United States by representatives of the National Coal Board a Goodman continuous mining machine has been built for use in this country by the Distington Engineering Company, Ltd., Workington, the licensees for the Goodman Manufacturing Company, which has a number of the machines in service in America. The British-built machine has concluded a series of trials at the N.C.B. Central Engineering Establishment, and is shortly to be placed in service at the Pentre-



Front end of continuous mining machine with a cutting area 7ft 6in high by 13ft 6in wide

clwydau Colliery in the South Western Division of the Board.

The general construction of the machine, which weighs some 32 tons, can be seen in the accompanying illustrations. With it a set profile 7ft 6in high and 13ft 6in wide is cut in the coal face by two large rotating cutter arms working in conjunction with a trimming cutter chain round the sides of the head. The machine is carried on crawler tracks which drive it into the working face as cutting proceeds. The displaced coal falls in front of the head and is gathered into a central opening from which it is carried back by a scraper chain conveyor. At the rear of the machine the coal is discharged by the conveyor at a height which is adjustable from 3ft to 6ft above floor level. The crawler tracks are independently driven and the drive is of sufficient power for the machine to work up gradients of 1 in 4.

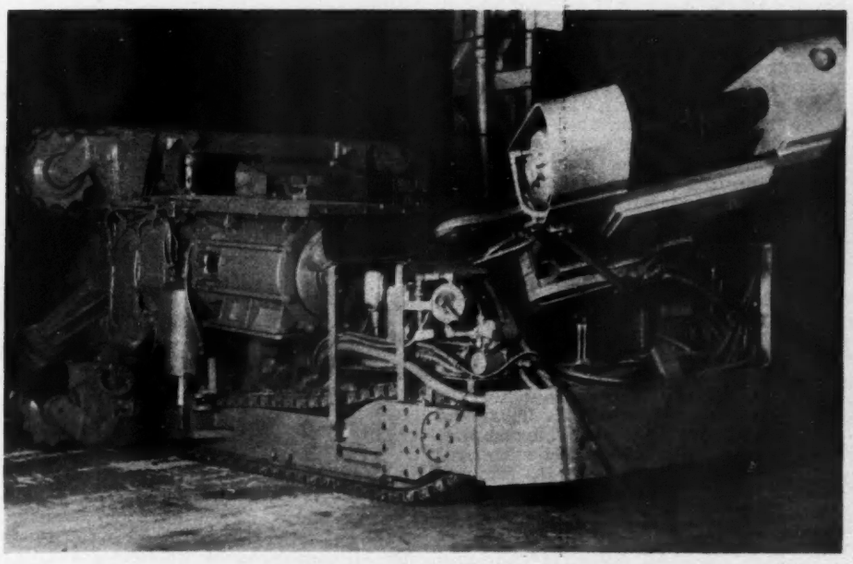
When the machine is in operation most of the coal face is cut and broken by the two contra-rotating assemblies, each of which is equipped with a double core barrel, two short arms, and two long hinged arms which lock in the extended positions. The tungsten carbide tipped cutting picks mounted on the arms cut two or three concentric kerfs in the face, and a further two kerfs are cut by picks on the core barrel. The shorter arms of the rotor are wedge-shaped, so that the cores between the kerfs are broken out as the machine advances, while each of the longer arms is equipped with a deflector plate. In conjunction with the forward movement of the machine, this cutter arrangement has the effect of directing the cut coal towards the central conveyor, on which it is carried back for discharge on to the main conveyor system of the mine. The discharge conveyor can be swung 40 deg. from centre line in either direction, and elevated up to 3ft above a minimum discharge height of 3ft.

The periphery of the cutting pattern is completed by the cutting chain which forms a kerf joining the concentric kerfs cut by the rotors. Cut-out sprockets on the corners of the chain result in a profile which is straight and wide across both top and bottom, and simplifies manœuvring of the machine and the setting of roof supports in its track. Wedge-shaped cutter bars at the top and bottom of the chain serve to break off that section of the face which is not reached by the rotating arms or the cutting chain.

The cutting head assembly with its 150 h.p. driving motor is supported on the main chassis of the machine through four hydraulic jacks by which adjustments can be made to enable the machine to follow irregularities in a seam. Two of these jacks give a lateral movement of the head of 5 deg. on either side, while the other two make it possible to tilt the cutting assembly up to 4 deg. forwards or backwards from the vertical. The independently driven crawler tracks enable the machine to be turned within a radius of 15ft to 20ft on the inside of the turn, without backing up. For tramming purposes the top and bottom cutting chain sprockets and cutter bars can be retracted and the long hinged arms of the rotors folded inwards.

The hydraulic system is fed by three pumps driven by a 37·5 h.p. motor. One pump supplies fluid for the hydraulic traction motors of the crawler drive ; one supplies power for the conveyor drive ; and the third pump serves the fifteen hydraulic cylinders operating the retraction mechanism, head tilting gear, and conveyor swinging and elevating gear. When high-speed tramming of the machine is required the output of the pump serving the conveyor drive can be used to supplement that of the track drive.

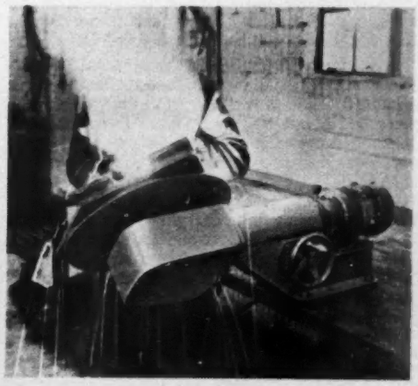
It is stated that the machine produces a good proportion of lump coal. Its cutting speed can be varied between 10in and 15in per minute when an output of from 3 tons to 5 tons per minute could be expected. The cutting speed naturally depends upon the nature of the coal being worked and the output per shift is controlled by the equipment available to remove the coal.



Rear end of continuous mining machine, showing delivery conveyor slewed to one side in the raised position

## Bench-Mounted Positioners for Welding

Two new bench-mounted welding positioners for 1 cwt and 2½ cwt maximum loads respectively have been introduced by Courtburn Positioners, Ltd., Kempston Hardwick, Bedford. The smaller machine shown in our illustration accommodates components weighing 1 cwt at 6in centre of gravity and 6in eccentricity. It has an 18in diameter top plate rotated at steplessly variable speeds from 0·25 to 2·25 r.p.m. by an electric motor driving through a mechanical variable-speed gearbox. The top plate can be rotated through 360 deg. by a handwheel on the side of the machine, and with the combination of full circle rotation and tilting motions a down-hand welding position can be used for all work.



Bench-mounted welding positioner with 18in table

The larger machine accommodates 2½ cwt at 6in centre of gravity and 6in eccentricity on its 24in diameter top plate, and is similar in design to the smaller model.

# SHORTER REPORTS

## London Helicopter Station

THE Minister of Housing and Local Government has approved the construction by Westland Aircraft, Ltd., of a helicopter landing station on the Thames at Battersea for a period of seven years, but has refused an application by Rotorports, Ltd., to build a heliport on the river between Lambeth and Vauxhall bridges. Public local inquiries into the applications were held during May.

The Westland proposal was for a T-shaped landing platform, on piles extending out over the foreshore of the river for approximately 100ft, for use during the next seven years. It will be designed to take an impact landing load of 15 tons—the requirement for the Westland "Westminster" forty-seater helicopter. There will be parking on land for at least five helicopters of the largest design now in use, or three "Westminster" machines, and for about twenty-two cars, and also buildings for flying control and passenger facilities.

The heliport will be available for use by all helicopter operators; it is estimated that during 1959 the average number of landings and passengers per week will be about twenty and 100–125 respectively, although these figures may be more than doubled during the Farnborough air show. It is expected that only medium-light helicopters carrying four or eight passengers will use the heliport in 1959 and 1960, and even after 1960 it is unlikely that medium-heavy or heavy helicopters will use it, except for operational research without passengers.

In his letter to Westland Aircraft, Ltd., giving permission in outline for the development, the Minister agrees with the inspector's conclusions that although the site—at the Belmont Works, York Road, Battersea—is unsuitable as London's main heliport, it is well suited for experiment and development with limited services for a limited period, and that aircraft and vehicle parking facilities to be provided are adequate. Bridges over the river are distant about 1000ft downstream and 2500ft upstream. He also agrees that while the noise of helicopters must cause some nuisance, it would be difficult to find a built-up area where noise was less likely to affect amenity.

Construction will begin next month, at an estimated cost of £62,000, and it is anticipated that the station will be in use before 1959.

Rotorports' proposal was to construct a platform about 100ft square mounted on three standard Thames lighters and moored to the river bed about 100ft from the Albert Embankment wall opposite the Tate Gallery. The platform was designed for a landing load of 6 tons—sufficient for helicopters seating ten to twelve passengers and would be large enough to take two small helicopters, carrying three passengers each, simultaneously. It could be extended and strengthened to take helicopters larger than ten to twelve seaters. It was intended eventually to provide a gangway between the Embankment and the pontoon, but communication would be by boat at first.

The company, which also was prepared to accept temporary planning permission for seven years, said that no great volume of air traffic was anticipated in the early stages, and aircraft movements would probably not exceed four to eight daily, mostly on charter flights. No special provision would be made for car parking.

The inspector reported to the Minister that the proposed heliport would take only one aircraft at a time. There was no space for parking aircraft and it would not be suitable for scheduled services. Unless a gangway was provided, access to the pontoon might be impossible at low tide. There was need for offices and passenger accommodation and for vehicle parking space off the street. There was likely to be considerable interference from noise to occupants of offices facing the Albert Embankment nearest to the pontoon.

The Minister saw no reason to disagree with his inspector's findings and recommendations, and in a letter to Rotorports, Ltd., refused permission for the proposed heliport.

## Large Dry Dock Project on Tyneside

A NEW dry dock is to be constructed by Vickers-Armstrongs (Shipbuilders), Ltd., near its existing dry dock at the Palmers Hebburn ship-repairing works on the Tyne. The dimensions of the new dock will be 850ft long by 145ft wide at entrance, with 35ft depth of water over the sill, and the dock will accommodate oil tankers of up to 80,000 deadweight tons. The dock has been planned so that extensions can later be made to lengthen the dock up to 1000ft, thus catering for the projected still larger tankers of 120,000 deadweight tons. The new dock in its first stage is planned to be open and ready for use by 1961. Messrs. T. F. Burns and Partners are the consulting engineers; the contractor is Marples Ridgway and Partners, Ltd. The new dock will be the largest on the east side of Britain. The company has acquired additional land adjoining the Palmers Hebburn Works, plus a further 600ft of jetty space and constructional work on the dock will be coupled with a programme for the modernisation and extension of plant, buildings and layout.

## Hydraulic Coal Mining Experiments in South Wales

AN experimental hydraulic coal mining equipment is to be installed at Trelewis Drift Mine near Treharris, Glamorgan. In this process the coal is extracted by the power of high velocity water jets directed at the seam from a monitor. When the coal has been broken down, the water jet is used again to clear the floor of the working place and to drive the coal along to the point of collection. In the initial trials the coal will be carried in the flow of water from the face into an open channel or flume and be carried to a screen where all coal above 2mm in size will be separated and transferred to the normal conveyor belt system. The slurry (a mixture of fine coal and water) will be pumped up a 6in diameter pipe to the surface of the drift mine where the fine coal will be removed and the clarified water returned to the system. If the trials prove successful steps will be taken to pump lump coal through the pipeline to the surface.

Mining at Trelewis is on the room and pillar system and the 1030ft long drift descends along a gradient of 1 in 4 to a point where it meets the 5ft 9in thick Brithdir seam, which in turn rises at a gradient of 1 in 14 and extends to a distance of about 2000ft. At present only the headings have been driven at this mine and it is proposed to start hydraulic mining on the pillars, starting from the highest point of the boundary and working backwards down the slope towards pit bottom, a method which will assist the broken coal to flow back more easily. The monitor will be placed at the end of a heading and its $\frac{1}{2}$in diameter jet will be projected at each side of the coal walls in turn. The Brithdir coal is of medium hardness and although it contains some bands of stone it is not anticipated that there will be any difficulty in removing it from the seam with the pressures available. It has been estimated that water pressure af 600 lb per square inch is sufficient to break down the softer coals and pressures up to 1200 lb for the hard and denser coals.

Only four men are needed to work each monitor—one to control the monitor and the others to attend to the pipes and flumes and fix supports. Russian experience suggests that production can be as efficient as in opencast mining, or between three and five times higher than with conventional methods, but there is no doubt that the only way to obtain reliable data regarding working pressures and the suitability of equipment is to proceed with pit trials.

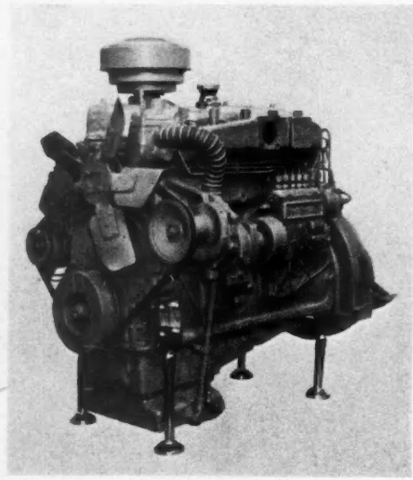
This hydraulic mining project is a sequel to the Board's interest in the hydraulic transport of coal by pipeline. Work at two installations, one at Woodend Colliery in the West Lothians, where coal is being pumped up a vertical shaft, and another at Markham Colliery, Derbyshire, where the haulage of lump coal through a 1000ft long pipe on the surface is being studied, will continue. The main object of these experiments is to develop more efficient methods of pumping and of transferring coal into a pipeline without losing pressure. The Trelewis project could be adapted for a hydraulic haulage system up the drift to replace the existing conveyors if the experiment in hydraulic mining proves successful. The cost of the trials is estimated to be £48,000 over a six months period, and mining is expected to begin at the end of 1958.

## High Output Vehicle Diesel

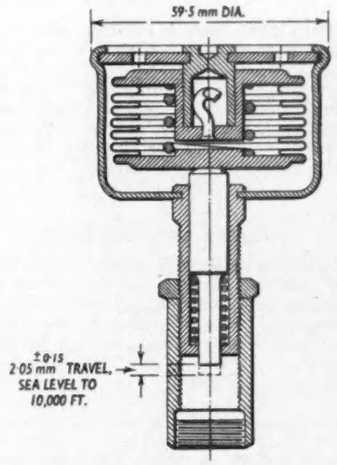
A BRITISH oil engine is to be optional in trucks of the "F.600" range of the Ford Motor Company; the engine will be sold as initial equipment and vehicles fitted with it will be available from all Ford sales and assembly plants outside the United States of America. The engine is the "F.340," a variant of the 340 cubic inch "R.6" of F. Perkins, Ltd., with a power output higher than that of the Mark II engines and more nearly equal to that of the original version at 110 h.p. at 2850 r.p.m.; the trucks have a gross vehicle weight of 19,500 lb.

The most noticeable modification to the engine is that the water pump has been moved from the front to the side of the cylinder block, in order to reduce the length of the engine at block height. Various design details show the influence of the higher operating speed; the three-row timing chain has an S.C.D. auto tensioner, the synthetic rubber slipper of which is held on to the chain by engine oil pressure, and there are four nylon pads inside the timing case to suppress chain whip. The ends of the valve stems are coated with "Stellite" in the case of the exhaust and flame hardened in the case of chromium steel inlet valves.

The available rate of injection of fuel has been increased by fitting a larger "AA" fuel pump, supplied by C.A.V., Ltd., and the pump has auto-



**The 340 cubic inch engine with centrifugal injection timing device. The altitude compensating control is not fitted to the fuel pump in this example**




**Altitude compensating device for vacuum governed fuel pumps: the pipe through which the capsule is evacuated is seen in the hollowed end plate**

matic altitude compensation effected by a bellows unit at the front; the capsule is evacuated and consequently has a movement linear with pressure, the travel being completed at 10,000ft—a vacuum governor is used, so that only a small force, which is itself density responsive, is tending to move the rack. Our illustration shows this device as fitted to the Perkins engine; for engines requiring excess fuel when starting from cold an alternative design has been evolved. A further elaboration of the fuel system is the installation of a Bosch centrifugal injection advance device.

## Fighter Fire Control

SOME general information has now been released concerning the radar-based interception controller which will be used in the English Electric "P.1B" all-weather fighter. The details released are consistent with earlier inferences that the interception includes the pilot in the control loop, rather than being fully automatic as in a Convair "Delta Dart."

Developed by Ferranti, Ltd., at Edinburgh, the system is called AIRPASS (Airborne Interception Radar and Pilots' Attack Sight System).

AIRPASS comprises a "very advanced" radar unit and a sighting system. The former gives information to the pilot in simple usable form, enabling him to intercept the target and lock the radar beam to it. Thereafter the radar accurately and automatically tracks the target; it feeds information to the sighting system where it is presented to the pilot in such a way that he can quickly and easily manœuvre into a suitable position from which to attack with guns, rockets or guided weapons. The sight ensures that the weapons are correctly aimed even though the target may be invisible to the pilot and travelling at supersonic speed.

In a typical interception, ground radar will direct the pilot in the general direction of the approaching target. AIRPASS will then take over. The radar beam will scan a sector of sky covering a wide angle, horizontally and vertically, on either side of the flight path, and extending many miles ahead of the fighter. When the target is located the radar will lock-on and a computer in the radar unit will automatically work out the best approach course for the pilot to follow.

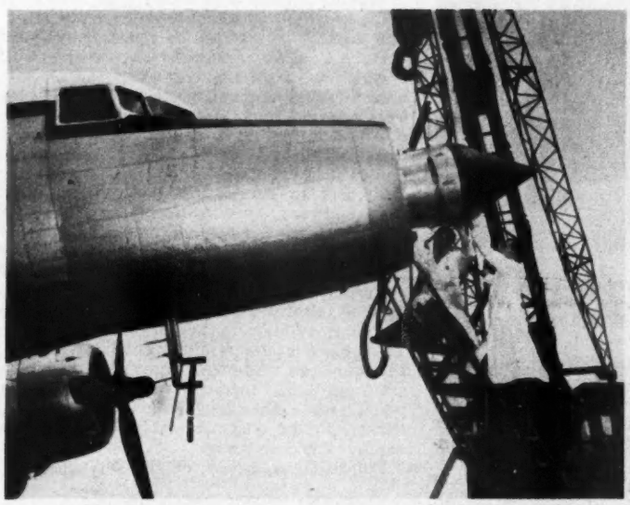
The pilot follows the correct approach and completes his attack using the information presented to him in his sight. The whole operation may be completed without the target ever being seen by the pilot, but if it should come into his view he can take advantage of the normal visual sighting methods which are included in the system. An automatic warning device is incorporated to tell the pilot when to break off the attack if he should approach close enough to be in danger of damaging his own aircraft.

In AIRPASS the radar unit is housed in a single container or "bullet." In the case of the English Electric "P.1B," the "bullet" forms a complete centre body in the engine air intake.

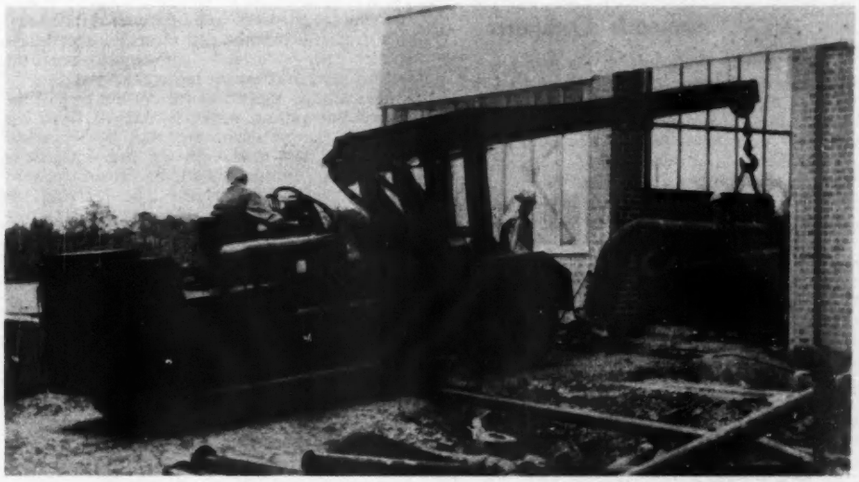
It has been reported that Soviet aircraft using the centre-body radome are confined to pursuit or lead-pursuit interceptions, and the same is likely to be true of this installation in view of the weapons available, cannon, unguided rockets, and the relatively unsophisticated D.H. "Firestreak"; collision interception demands either an extreme rate of aimed fire or a missile with immense manœuvrability and a highly "intelligent" fusing system. A considerable saving in weight is effected by the elimination of the usual number of boxes and interconnecting cables, presumably at a sacrifice in speed of inspection and rectification.

The packaged design of AIRPASS is small enough to be installed even in lightweight fighters, we are informed, the computer being actually contained within the "bullet."

AIRPASS was demonstrated near Bonn (June 10 to 13) to senior officers of the West German Air Force; demonstrations have been given to other Allied countries who have shown interest in AIRPASS. The Douglas "Dakota," illustrated, and an English Electric "Canberra" have been used for flight tests.



**The radar and fire control assembly is installed in a "Dakota" modified to house a circular nose like that of a "P.1B"**



**Hydraulically operated mobile crane with a maximum capacity of 4½ tons at 8ft outreach from front bumper**

## Mobile Crane

A MOBILE crane with hydraulically actuated motions throughout, which is now being made by R. H. Neal and Co., Ltd., Plant House, Ealing, London, W.5, is illustrated above. The telescopic jib of this machine can be slewed up to 60 deg. on either side, extended to give a working radius from 8ft to 16ft and raised to give a maximum lift height of 20ft. At the minimum outreach of 8ft from the front bumper, with the jib in the fore and aft position and fully retracted, the maximum lifting capacity is 4½ tons; with the jib fully extended to give a maximum outreach of 16ft, the maximum load which can be raised is 2·7 tons.

The frame of the machine is a welded assembly of two heavy rolled steel joists, which run the full length of the chassis and are well cross braced and enclosed by a steel plate shell. The four-cylinder Ford diesel engine, which develops a maximum of 61·5 b.h.p. at 2250 r.p.m., is integral with a four-speed gearbox and an additional reduction and reverse box, giving four crane speeds in forward or reverse of 2, 4, 8 and 12½ m.p.h. A Hardy Spicer propeller shaft connects the gearbox to a heavy duty spiral bevel front axle with a differential and fully floating half-shafts. The twin wheel rear castor is equipped for power assisted steering and gives the machine a turning circle of 16ft radius. A Hamworthy pump supplying the hydraulic system is mounted in a readily accessible position at the rear, and driven by power take-off from the engine crankshaft. Individual control valves provided for each motion are also of Hamworthy manufacture.

The inner section of the rectangular mild steel telescopic jib runs on rollers and its 8ft stroke is effected by a hydraulic ram. A hoist cable, which is designed to carry the maximum crane load on a single line, is operated by a 6in diameter double-acting hydraulic ram and 10ft of free hoist cable is available in all jib positions. The jib is pivoted on heavy brackets at the rear and is derricked by a pair of 7in diameter hydraulic rams. The complete jib assembly is mounted on a slewing turntable carried on rollers and turned by two double-acting rams.

In the unladen condition the crane weighs just over 12 tons, and a particular point in its construction emphasised by the makers is that with the jib in a horizontal position the machine is only 7ft 11in high so that it can be driven through a doorway only 8ft high.

Another recent development of this firm is the introduction of a hydraulically-operated cantilever jib on its "H.S.70" mobile crane. This fully slewing mobile crane has a maximum rating of 6 tons at 10ft radius when fitted with a 25ft jib and ½ ton at 44ft radius when fitted with a 50ft jib.

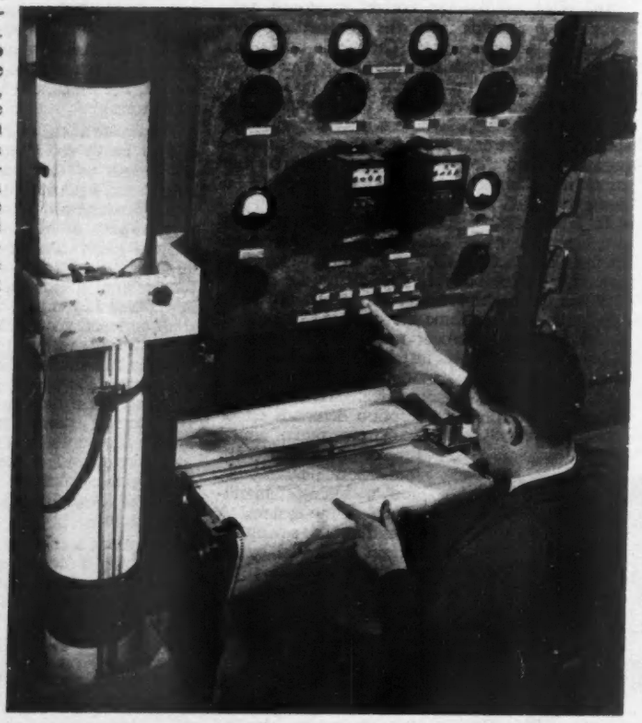
## B.T.C. Analogue Computer

THE British Transport Commission has installed a special analogue computer in the office of the Chief Electrical Engineer, British Railways Central Staff, for determining train performance with the new forms of power introduced under the Modernisation Programme. The advance information obtained will be used to revise timetables so as to get the maximum use from the new equipment. The information is required long before the trains enter service, usually at the design stage. From the known data for a type of locomotive or train, and details of a particular line, e.g. gradients, speed restrictions, and stopping places, it is straightforward to work out the time to travel from one place to another. However, the work can be substantially speeded-up by the use of a computer.

The B.T.C. analogue computer was developed and built under the direction of Professor E. Bradshaw of Manchester University, in association with the Chief Electrical Engineer. Voltages are used to represent the physical quantities. To solve a train performance problem the tractive-effort/speed characteristic of the locomotive or train is drawn, and a suitable train-resistance curve and a punched tape of the gradients of the route are selected. The positions of all stations, speed restrictions, &c., are marked on a 24in chart, and braking curves are drawn backwards from each stop and from each speed restriction. The results are displayed as a continuous record of speed against distance, with an independent time trace.

*Integrators.*—Modified watt-hour meters are employed to solve the two equations $v = \int a\,dt$ and $s = \int v\,dt$ where $v$ denotes speed, $a$ acceleration, $t$ time, and $s$ distance. A stabilised voltage is applied to the voltage coils, and to the current coils are fed voltages representing the variables.

The voltage applied to the current coil of the first integrating meter, representing net tractive effort, is derived from three sources: (*a*) a "Variac" auto-transformer driven by a mechanism following the tractive - effort/speed curve, or an auto transformer adjusted to the appropriate braking rate; (*b*) a "Variac" auto-transformer driven by a mechanism following the train-resistance/speed curve; (*c*) a transformer having a secondary winding tapped to provide turns ratios of 1 : 2 : 4 : 8 : 16 : 32 : 64; this introduces the effect of a gradient. Information on gradients is punched on a tape in a binary coded form and picked up by knife-edged roller contacts. Relays controlled by the roller contacts select the appropriate transformer tappings, a total of 127 different combinations being possible using the seven sections of the winding, and auxiliary relays, also controlled by roller contacts, control the sign of the gradient voltage.



**The 24in chart on which the positions of stations, speed restrictions, &c., are marked for use in the British Transport Commission's analogue computer. Braking curves are drawn backwards from each stop and each speed restriction**

The angular velocity of the disc in this first integrating meter is proportional to acceleration and its displacement is proportional to speed. The edge of the disc is painted in alternate black and white segments, and light from a lamp built into the meter is reflected from the white sectors on to a photo-electric cell. Signals from the photo-electric cell pass through a phase discriminator and shaping and differentiating circuits to uniselectors which drive the drum carrying the curves of speed-dependent functions; this in turn drives the pen recording speed, and rotates the "Variac" auto-transformer, the output voltage of which represents speed.

The voltage applied to the current coil of the second integrating meter is derived from the "speed" auto-transformer, and, by a method similar to that used with the first integrating meter, the distance chart is driven forward together with the punched tape carrying the information on gradients.

A small synchronous motor provides a time trace of saw-tooth form by means of a cam-following mechanism and pen.

*Curve Followers.*—We have already referred to the automatic curve-following device. This operates as follows. Two probes approximately 2mm apart straddle each curve of a speed-dependent function (tractive effort, train resistance, motor current). A broad band of conducting, colloidal graphite is painted immediately below the curve and connected to earth. The probe-unit driving motor, a permanent magnet d.c. machine, which also drives the "Variac" auto-transformer associated with that curve, is fed via two relays, according to signals received from the probes. If both probes are on the graphite, i.e. below the curve, the motor winds them up, and if both are off the graphite, i.e. above the curve, the motor winds them down. In this way the probes follow the curve as it is rotated by the uniselectors and in their normal position, astride the curve, the driving motor is disconnected from the supply.

*Energy Consumption and Motor Temperature.*—As mentioned above, provision is made on the main chart drum for a third speed-dependent function, motor current in the case of an electrically hauled train, and an automatic curve following mechanism drives a "Variac" auto-transformer feeding an unmodified kilowatt-hour meter. This integrates current with respect to time and records the result on a counter. The product of current-consumption and line voltage provides a continuous record of energy consumption.

The computer will also integrate the square of the current with respect to time, giving an indication of the temperature of the traction motor. This permits the performance of the motor to be related, after any duty cycle, to the machine's continuous or one-hour rating. The method is to gang a second "Variac" auto-transformer mechanically with the one for motor current, and arrange the output of the first to be the input to the second. A fourth kilowatt-hour meter then integrates the output of the second "Variac," $I^2$, with respect to time. Again the result is displayed on a counter.

## Radar for Airways

FOR equipping the new air terminal at Stockholm and the airport at Gothenburg with up-to-date long range air surveillance facilities, a substantial contract, placed by the Swedish Board of Civil Aviation, has been gained by Decca Radar, Ltd.

The radar equipment to be supplied is the Decca "A.S.R.1," an S-band, 800kW radar providing gap free coverage to long range and to heights above the 40,000ft level on the smaller types of modern air liner. The actual performance against a target of 24 square metres equivalent reflecting area is continuous from 10 to 135 miles at 50,000ft.

An aerial system of advanced design is used, consisting of two reflectors mounted back to back. Each is fed from a separate 800kW transmitter and radiates an overlapping beam of energy. Such a two-beam system has important advantages over conventional cosecant-squared, single reflector types, we are advised. Operationally, the size of the aerial is smaller for the same performance because the two beams are highly directional and allow the most efficient distribution of the available power, the lower beam providing the maximum long range performance that can be realised whilst the upper ensures that high altitude cover is maintained in to close range. The radiation pattern also allows full advantage to be taken of a new form of ground echo suppression.

The method of ground echo suppression used is known as Air Target Indication (ATI). This system has important advantages over the older and more conventional M (moving) TI methods. It consists essentially in the exploitation of the aerial gain pattern in combination with sectorised beam blanking over certain range brackets, logarithmic receiver characteristics, and swept gain. The system was originally developed in order to provide permanent echo suppression without resorting to the considerable electronic complications of the MTI methods, with their consequent maintenance and serviceability problems. For civil radar stations the system is particularly suitable because it will always function at full efficiency after initial setting-up on installation. It is inherently fail-safe and has no blind speed or radial course limitations. Sub-clutter visibility values vary over the coverage pattern but they average over twice those normally obtained in service by the MTI method in high altitude surveillance radars.

Another unusual feature in a radar of this size is the provision of completely variable polarisation control. This can be remotely operated from the display position and enables the operator to select any form of polarisation—horizontal, elliptical or circular—to suit prevailing weather conditions. This technique of variable polarisation has, it is claimed, been tried and found satisfactory, even under monsoon conditions; the polarisation control enables the equipment to be adjusted so that dangerous storm centres are just visible on the displays, in order that aircraft may be vectored round them.

The displays used with this new radar are of the Decca "Interscan" series which have particular operational advantages since a great deal of information can be electronically displayed, in addition to the normal radar picture. To do this a technique of interlaced scan is used; interscans can take many forms such as runway extension lines, marker symbols for holding points, &c. The design allows this type of facility to be increased as the operational requirement develops.

Principal parameters of the D.A.S.R.1 are:

| | |
|---|---|
| Aerial horizontal beam width to half-power points | 0·95 deg. |
| Pulse length | 2 μs |
| Rotation rate | 10 r.p.m. |
| Pulse repetition frequency | 300 per second |
| Receiver noise factor | Better than 9 dB |

# Industrial and Labour Notes

### Railway Shopmen's Wages

The British Transport Commission has offered a 3 per cent wage increase to the 120,000 or so engineering workers employed in British Railways' shops. The unions concerned are constituents of the Confederation of Shipbuilding and Engineering Unions and had asked for a "substantial increase." The union reply on the present offer is to be made known later this month.

In making this offer, the British Transport Commission has kept in mind the wage settlement for other railway staff which was agreed with the three railwaymen's unions during May. The 3 per cent increase in their case came into operation this week. The offer now made to the shopmen includes a promise of a further review of wages as may be necessary later this year. But the British Transport Commission has emphasised that the increase offered must be met out of its resources. The offer is made, the Commission says, on the understanding that the trade unions reaffirm their willingness to co-operate in the development of the railway modernisation programme and in measures necessary to secure the maximum productivity and economic working of the railway industry.

### Industrial Disputes

The Ministry of Labour's most recent statistics of stoppages of work through industrial disputes in the United Kingdom show that, in the 247 stoppages in progress during the month of May, 106,400 workpeople were involved and the time lost amounted to 1,451,000 working days. This considerable increase in the time lost, compared with recent months, resulted, of course, from the London bus and dock strikes. These stoppages accounted for approximately 1,267,000 of the total number of working days lost during May.

In the first five months of this year, the Ministry reports, there were 1238 stoppages of work through disputes. They involved 287,900 workpeople and caused an aggregate loss of 2,045,000 working days. In the comparable months of last year, there were 1244 stoppages involving 991,700 workpeople. The time then lost amounted to 6,845,000 working days, which included nearly 5,000,000 days lost by the engineering and shipbuilding strikes in the spring of 1957.

### Overseas Trade

The Board of Trade's latest survey of the United Kingdom's overseas trade says that the value of exports in May was £287,300,000, which was £22,000,000 more than in April and the highest figure recorded for a year. The value of re-exports, £14,600,000, was nearly £3,000,000 higher than in April. The value of imports fell slightly to £308,400,000, a result that was influenced by the first effects of the London dock strike. These figures show that the visible trade gap was reduced in April to £6,500,000.

The Board of Trade says that, even without the distorting effect of the dock strike, it is clear that the big improvement this year in the balance of overseas trade would have been fully maintained in May. But, it is added, the rise in exports in May, which is usually a good month, was probably no more than seasonal and hardly implies a change in this year's "slight downward trend." If April and May are considered together, exports were 3½ per cent lower in value than in the corresponding period last year, against a fall of only 1 per cent for the first quarter. With the overall level of export prices now much the same as in the first half of 1957—although prices for manufactured goods are still rather higher—the fall in value this year is wholly accounted for by a reduced volume of shipments.

In April and May, the engineering group remained the most buoyant sector of exports, despite some slackening of the recent marked rise in motor-car exports. Declines in some other export sectors, notably textiles and solid fuel, have become steeper. On the figures for the two months, the rise in shipments to the sterling area appears to be ending, and exports to the dollar area also seem to be tapering off, although the figures for May alone were encouraging with shipments to the U.S.A. remaining substantially above last year's level. But exports to Western Europe in recent months have been well below the 1957 level.

### Human Relations and Efficiency

A conference on "Employment Policies," arranged jointly by the Ministry of Labour and the Institute of Personnel Management, was held at Cambridge last week-end. It was opened on Friday evening by the Hon. Richard Wood, Parliamentary Secretary to the Ministry of Labour, who emphasised that efficiency and high productivity throughout industry were dependent on individual firms finding the solution to the human problems within their establishments. Mr. Wood said that when, as now, changes were taking place in the techniques of production, in processes and in the demands for skill and different kinds of work, a dynamic approach was essential if a firm was to be ready to meet the demands on its economy and to face competition.

Such an approach, Mr. Wood continued, needed adaptability in organisation and in the use of resources, and it inevitably involved strains on individuals and on groups at all levels. That situation, he urged, could only be faced successfully when good relationships, confidence and respect existed between managements and workers. Such relationships were not easily attained, Mr. Wood commented, particularly in a complex society like this country's, where various, and often conflicting, influences and traditions had caused people to look at matters from very different points of view. There was no doubt, he added, of the great importance which the Government attached to the development of good relations.

Mr. Wood went on to refer to the Carr committee's report on "Training for Skill" and particularly to the recommendation that a national apprenticeship council should be set up. He said that the British Employers' Confederation, the Trades Union Congress and the boards of the nationalised industries had decided to set up such a council which, he hoped, would come into being in about a month's time. There was no doubt, Mr. Wood continued, that industry recognised its responsibility for providing sufficient training places in the next few years; the apprenticeship council was not a Government decision, but the desire of industry itself. At the same time, Mr. Wood went on, the Government clearly recognised its own responsibilities. It was conscious of the difficulties for industry during the present slowing up of economic activity and was thinking out ways and means by which industry might be helped to overcome those difficulties. But, he pointed out, it was no use waiting for the Government to do the whole job. The kind of collective action which was required needed leadership and co-ordination and, in the Government's view, the leaders and co-ordinators must come from industry. That was the function for which the forthcoming training council would be responsible.

### Industrial Activity

The Treasury has stated that the index of industrial production (1948=100) is expected to be between 138 and 139 for all industries in May. Last year, the index number for May was 145. This year the figure for May was affected, of course, by the Whitsun holiday. In the first five months of this year, however, the index averaged 140, compared with 141 in the corresponding period of 1957.

Speaking in Manchester last Friday, the Chancellor of the Exchequer, Mr. Heathcoat Amory, said he was convinced that first priority must be given to the encouragement of exports and a "close second" to the stimulation of productive investment. The encouragement that had been given recently to industrial investment, the Chancellor commented, was, of course, related to the long term. It was likely to affect the thinking and forward planning of business men rather than to have an immediate effect on the situation in the next few months.

One of the most heartening features of this country's economic experience in the past four or five years, the Chancellor claimed, was the rise in investment from 15 per cent of the gross national product in 1952 to 17½ per cent last year, and the even more remarkable increase of personal saving which had helped to make that possible. On the subject of wages, the Chancellor said that though there had been some disquieting evidences of settlements which seemed to go beyond any likely increases in productivity, he thought there were the beginnings of a more realistic approach. The wage increases given in the main had tended to be smaller than those in the two preceding years, though some major claims were still outstanding. It was as well, for our national future, he declared, that there should be signs of moderation in the inflationary wage cycle which had been experienced since the war. There were now good reasons, he added, for expecting some prices to be falling. There had been a sharp decline in the cost of imported materials and wages had been rising less rapidly. It was right to expect a response in industry to those influences. The wholesale price index of manufactures, the Chancellor pointed out, had now been stable since last autumn, after rising almost without a break for three-and-a-half years.

# Seventh International Technical Congress of the F.I.S.I.T.A.

No. II—(*Continued from page 987, June 27*)

DR. MAX BRUNNER (Switzerland), Professor at the Polytechnicum, Zürich, reported on "Some Experiments on Multi-grade Lubricating Oils," dealing in particular with their behaviour at low temperature and the drop of their viscosity index.

The author showed that rheological measurements, employing shearing stresses of varying magnitude, had made it possible to ascertain with accuracy the reaction of S.A.E. 10 W and S.A.E. 10 W/30 lubricating oils to low temperatures. The experiments proved the efficiency of the additives which are generally employed to lower the coagulation point, including those which, at the same time, improve the viscosity index.

From a study of several representative S.A.E. 10 W 30/multi-grade oils, used in various petrol-engined vehicles, it appears that in the majority of cases the permanent lowering of the viscosity observed is easily explained by the dilution of the oil caused by the presence of condensed fuel. In a few isolated cases only, a further lowering of the viscosity index—though still keeping within the acceptable limit—could be attributed to the depolymerisation of the additives intended to improve the viscosity index. Compared with the permanent lowering of the viscosity index of the conventional S.A.E. 10 W oils resulting from dilution by fuel condensate (a phenomenon which cannot be avoided), the temporary lowering of the apparent viscosity, caused by the considerable shearing stresses in modern high-speed engines, generally keeps within tolerable limits.

An analysis of a fairly large number of used S.A.E. 10 W engine oils has shown that in one case only out of every four had the viscosity index dropped from 1 to 3 points below the dispersion zone of about 137–141 (including differences in the viscosity index of the new oil plus the tolerances admissible at the determination of the index). This, together with the comparatively rare viscosity drop due to depolymerisation, conclusively proves the high resistance to mechanical and thermal stresses of the additives used to improve the viscosity index.

Monsieur Yves Bresson, chief metallurgist of the Research Laboratory of Cegedur, Issoire (France), and Messieurs C. Guinard and M. Renouard reported on "Recent Progress in Light Alloys for Motor-car Bodies."

Light metal sheets used in France for motor-car bodies are almost exclusively made of annealed 3 per cent magnesium-aluminium alloy (A-G3). Recent improvements, particularly in the milling process of sheet metal, have led to the development of the A-G3 "pressing" alloy, the elongation of which is about 5–7 per cent higher than that of the normal A-G3 sheet metal. This alloy, which has been extensively used for the manufacture of more than 20,000 Dyna-Panhard bodies, has proved an excellent material for pressed parts.

However, it is desirable to employ for car bodies an alloy which offers a local rigidity comparable to that of steel, without the necessity of increasing the thickness and, therefore, the weight and the cost of the panels. Comparative test with an aluminium alloy containing 2·5 per cent Cu and 0·4 per cent Mg have proved very successful; this new alloy, labelled A-U2G, has a greater local resistance to "blistering" than the A-G3 and, after air hardening and ageing for one or two months at ambient temperature, offers completely stabilised mechanical properties. It allows for approximately the same deep-drawing as the A-G3 material, but has several advantages. For a thickness of 1·2mm the local rigidity is comparable to that of 1·4mm annealed A-G3 alloy or of 0·95mm sheet steel. It is not sensitive to "vermiculation," and under certain conditions it can be spot-welded without preliminary cleansing or degreasing. This alloy is suitable for all panels and other pressed components of car bodies and, especially, for such vulnerable parts as wings.

The authors of this paper then dealt with the question of panels for commercial vehicles and recommended the use of annealed and stabilised A-G3 or A-M1 (aluminium-manganese) alloys which have a high yield strength and sufficient elongation to allow folding.

Monsieur Albert Beaujean (Switzerland), of the Westinghouse Company, Ltd., Bern, dealt with the topical subject of the "Present Stage of the Development and the Evolution of the Pneumatic Suspension as Applied to Motor-Coaches, Lorries and Passenger Cars."

The suspension of motor vehicles has engaged attention for some considerable time. It has been well known that air was an element particularly suited for use in a suspension system, but, until lately, the design of such a system was greatly hampered by the fact that the elastic substances suggested for the suspension components did not possess the required properties as far as strength and life were concerned. Recently, the progress achieved in the processing of rubber and synthetic materials has made it possible to produce the kind of bellows required by pneumatic suspensions. The first vehicles equipped with "air springing" were marketed in the United States about six years ago. Lightweight construction, which nowadays is the rule in most countries, compels manufacturers to pay the closest attention to improved suspensions, as the greater ratio of payload to deadweight makes it more and more difficult to design a suspension which provides favourable spring characteristics under widely varying load conditions.

All steel springs, irrespective whether coil springs, blade springs or torsion bars, have only one spring characteristic which, in the case of leaf springs, is unfavourably affected by rust and dirt between the individual leaves. Changes in the floor level due to load variations adversely affect the flow of passengers, especially of motor-coaches. Hard suspensions tire passengers sooner and do not offer the comfort essential for long-distance travel.

In contrast with steel springs, pneumatic suspensions provide a variable spring characteristic according to the load conditions, so that a constant floor level can be maintained. Further, the transmission of road-excited vibrations to the superstructure is reduced, and the road holding of the vehicle, especially when lightly laden, is improved as the wheels show little tendency toward "jumping."

The pneumatic suspension also offers the opportunity of designing without great difficulties a braking system the efficiency of which corresponds to the load and is directly related to the air pressure inside the bellows. Such a system, which should effectively prevent the locking of the wheels of an unloaded vehicle, could usefully contribute to road safety.

Adequate testing and measuring methods are, of course, necessary to assess the properties of air suspensions in comparison with the present steel spring suspensions. The author gave details of the means employed by himself in these tests and showed some interesting oscillograms of orthodox and pneumatic suspensions. Fig. 9 demonstrates clearly how the vibrations caused by steel springs vary considerably with the load of the vehicle, while those of the air suspension remain practically constant irrespective of the load.

The almost universal adoption of the frictionless steel spring (coil spring or torsion bar)—mainly for front suspension—has confronted the designer of suspension dampers with a number of difficult problems, which might become still graver if the air suspension should find a wider application. For this reason a paper read by Dr. H. J. Hoffmann (Germany) on "Theoretical and Practical Investigations on the Efficiency of Motorcar Shock Absorbers," based on the author's research work carried out at the Technical University, Brunswick, raised considerable interest.

In order to ascertain the efficiency of telescopic suspension dampers, a test rig was devised which allowed measurement of damping effect in relation to piston speed and travel. The accuracy of the measurements was checked with the aid of an adjustable test damper, the characteristics of which were determined by calculation. The characteristics of standard dampers and their damping factors could be recorded on the test bed.

For a given test vehicle, the following factors were determined :—The masses of the axles and of the body, the spring and tyre characteristics, the centre of gravity, the moment of inertia relative to the transverse axis passing through the centre of gravity, and the damping due to the inherent friction of the system. The results showed that the vehicle oscillates about a fixed rotational axis. The relations between these results, which were examined in detail, made it possible to set up an equivalent mechanical system, capable of being analysed by mathematical means.

Oscillation tests of the vehicle were carried out on a test bed, the rotating drums of which were driven at various speeds by an electric motor; road obstacles were simulated by a succession of sinusoidal cams fixed to the circumference of the drums. The travel thus excited, and the acceleration of the axles as well as of the superstructure, were measured, and the influence on the character of the oscillation of single- and double-acting dampers was examined. The test results showed that a damping effect of $D=0{\cdot}25$ can be considered sufficient. ($D=k/k_{ap}$ is defined as the ratio of the factor $k$, indicating the damping of an oscillatory system at linear velocity, and $k_{ap}$, denoting that of the aperiodic limit.)

The results obtained by experimental tests can be mathematically checked by the approximation method. Proof was thus obtained that the simplified equivalent mechanical system behaved like the test vehicle, so that further investigations could be pursued on a theoretical basis. Oscillation behaviour was examined with an electronic analogue computer for various adjustments of suspension dampers, leading to the conclusion

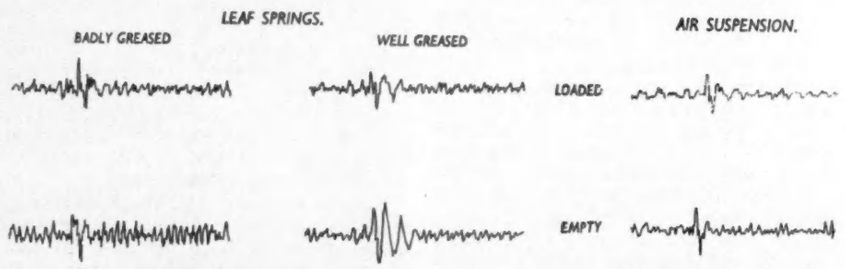



**Fig. 9—Acceleration of a motor-car body caused by one bump at 25 m.p.h.**

that a double-acting damper with a uniform effect in bounce and rebound, proportional to the square of the piston speed, ensures a maximum of safety and riding comfort.

The analytical method can be expected greatly to assist the designer in facilitating the correct adjustment of suspension dampers for a given vehicle. Moreover, the introduction of air springing may make it possible to devise dampers the damping characteristic of which varies with the load, by utilising the air pressure in the bellows for controlling the hydraulic flow through the damper valves.

Monsieur Herman Van Speybroeck (Belgium), in his paper " Contribution to the Study of Some Vibrations in Vehicles by Means of a Simulated Road Surface," reported about his investigations on the question of measuring road-excited noise and vibrations. The author maintained that the study of vibrations with a frequency ranging from 1 to 100 c/s which are generated in three orthogonal directions of the vehicle, can most conveniently be performed with an " artificial roadway." The test rig used by the author employed electrically driven steel rollers of 600mm diameter, covered with a 100mm thick layer of reinforced concrete. The road surface was simulated by one or several cams, ranging in height from 20mm to 50mm, fixed to the circumference of the drums. The mechanically excited vibrations up to a frequency of about 15 c/s were measured with sufficiently sensitive accelerometers, the higher frequencies (noise) by electronic instruments.

A test bed of this kind makes it possible to ascertain the part played by each of the three vehicle axles in the transmission of vibrations of different frequencies caused by the road surface. An analysis of tests carried out with vehicles of different design, but all intended for public passenger transport, clearly showed the effect of the constructional layout of the vehicle on the transmission of vibrations, and thus on the passenger comfort.

The testing of vehicles on roller test beds has of course to be supplemented by road tests in order to obtain accurate results. Messieurs P. Devergne and J. P. Thiry (France) dealt with " The Possibilities of Telemetering in Motor-Car Tests," a modern method already extensively used in the testing of aircraft. Compared with the conventional method of direct or recorded measurements, generally employed for road tests of vehicles, telemetering offers considerable advantages. The equipment carried in the test vehicle consists of a few small and light instruments, namely, the pick-ups, the modulator stages assembly, and the radio transmitter which, in view of the short range required, does not require a high output and can easily be supplied with current from the vehicle battery. The pick-ups transform any variations of acceleration or pressure into a displacement which in turn is converted into a variation of a self-inductance. The transmitter emits the signals received from the pick-ups ; simultaneous transmission is possible on five channels, the frequency range of which may vary between 0 and 400 c/s.

The receiving station, preferably installed in a light van, contains the radio receiver and the various recording instruments, a multiple mirror galvanometer and, for direct readings, a cathode-ray oscillograph. The receiving station can easily be adapted to the particular requirements of the testers and, with standardised pick-ups, it is possible to compare immediately the results obtained on several cars transmitting successively on a given point of the track.

Members of the audience were given the opportunity of viewing the telemetering equipment, made by the Société de Fabrication d'Instruments de Mesure, Massy, and to attend a demonstration.

Mr. C. G. Giles and Mr. F. T. W. Lander (England), of the Road Research Laboratory, Harmondsworth, in their paper on " The Skid-Resisting Properties of Wet Surfaces at High Speed," reported on experiments carried out in a study of braking on roads and airfield runways. The object of their investigations was to determine the possibilities of a simple measuring system and to examine the non-skid properties of runways at speeds between 50 and 100 m.p.h.

The test equipment consisted of a fast car, pulling a single-wheel trailer which carried a fixed load and was fitted with a servo-operated disc brake, capable of locking the wheel instantaneously. An arm attached to the brake cylinders bears upon a hydraulic gauge, thus registering the pressure during the retardation. The brake is applied for a few seconds at a time on roads previously sprayed with water at speeds which, between maximum and minimum, varied in stages of 10 m.p.h. The coefficient of friction between tyre and road was regarded as the ratio of the pressure registered at the gauge at the locking of the wheel (equivalent to the friction at the circumference of the tyre) and the static load.

Tests were carried out with 16in×4in tyres of smooth and patterned design on seven standard runway surfaces (macadam with and without gravel, and concrete with a bitumen surface). The results confirmed prior investigations, namely, that the coefficient of friction varies between 50 and 100 m.p.h., almost in the same proportion as it does between speeds under 30 m.p.h. It decreases as the speed increases, and depends to a great part on the nature of the road surface and the tread pattern of the tyre. Values obtained on wet surfaces yielded the following coefficients :—

| | |
|---|---|
| Smoth tyre tread : | |
| Smooth runway ... ... ... ... ... | 0·1 |
| Rough runway ... ... ... ... ... | 0·4 |
| Average ... ... ... ... ... ... | 0·24 |
| Patterned tyre tread : | |
| Smooth runway ... ... ... ... ... | 0·2 |
| Rough runway ... ... ... ... ... | 0·5 |
| Average ... ... ... ... ... ... | 0·31 |

On a dry surface the coefficient lies between 0·7 and 0·8, according to speed and surface.

The reduction of the coefficient on wet surfaces is to be attributed to the presence of the film of water between the tyre and the surface. With a smooth tyre, the contact surface is wide and unbroken, the contact pressure is low, and the water trapped between the tyre and the road surface acts as a lubricant. With a patterned tyre, having a number of ribs, notches or fine cuts, a certain draining effect takes place ; the establishment of a direct tyre-to-ground contact, however, is mainly a function of the texture of a suitable road surface; such a surface, even with a smooth tyre, provides a good " drainage " as the zone of contact consists of a number of small and fairly widely spaced areas from which the liquid film may readily escape in all directions.

## E.C.S.C Council of Association Meeting

The coal and steel situation in the United Kingdom and the countries of the European Coal and Steel Community was considered at the seventh meeting of the Council of Association between the United Kingdom Government and the High Authority of the E.C.S.C. which was held in London on June 12. The Council instructed its Coal Committee to consider mutual trade in coal between the United Kingdom and the Community on a long term and if possible on a permanent basis. It also instructed its Committees to keep the market situation under review. United Kingdom representatives explained that coal demand continued to be slack, and although productivity had improved in recent months, output was below the 1957 level. Future market prospects would depend upon the level of industrial production.

The High Authority representatives said that in the Community, production in the first five months of the year had been at about the same level as in 1957, this taking into account the introduction in certain mines of short time due to the excessive level of pithead stocks. Overall demand had weakened and exports had fallen sharply. Stocks held by consumers remained for the most part at the same high level as that reached last year.

Concerning steel the Council noted that the rate of increased production achieved in 1957 (about 5 per cent above that of 1956 both in the Community and in the United Kingdom) was not being maintained in 1958. The future lev l of production was difficult to predict ; there was hesitation in placing new orders for a number of products.

The supply of scrap available to the Steel industry in both the United Kingdom and the Community was found to be easier.

In the field of commercial relations the Council took note of the progress made in implementing the Tariff Agreement on iron and steel products. This, it will be recalled, was signed in Luxembourg on November 25, 1957, between the United Kingdom and the Community ; the new rates of duty have been brought into force by the Community countries on February 10, 1958, which was the end of the transitional period provided in the Treaty setting up the Community, and by the United Kingdom on April 28. This is the first concrete step towards the reduction of tariffs between the United Kingdom and the Community.

The Council also took note of the Belgian Government's decision, of which the United Kingdom Government had been notified, to impose restrictions on coal imports from non-Community countries. Given the small volume of the exchanges involved, it was agreed that this measure was unlikely to have serious repercussions.

## Continuous Casting Plant For Steel

On April 19, 1958, the second Schloemann vertical continuous casting plant, designed according to the Rossi-Concast system, was put into operation at the plant of Paderwerk, Gebr. Benteler, Schloss Neuhaus/Paderborn, Germany. This one-strand plant, laid out for a monthly output of 5000 tonnes, is fed by a 17-tonne tilting ladle to produce billets 4¼in by 6¼in square, and later on also 11¾in by 2¾in. The billets are cut to lengths of between 10ft and 20ft and serve for the manufacture of precision seamless steel tubes. Messrs. Paderwerk, Gebr. Benteler, intend to restrict the production of chilled castings to a minimum, and to produce in the continuous casting plant all initial material for the making of steel tubes.

## Meeting of Federation Européenne de la Manutention

The eleventh meeting of Section IV of the Féderation Européenne de la Manutention, which deals with industrial trucks, was held in Baarn, Holland, on May 28 and 29, 1958, when thirty-five delegates from ten European countries were present.

During the course of the deliberations it was decided to adopt the resolution of the previous meeting which took place in Vienna that all rider-controlled 3- or 4-wheel fork trucks up to 10,000 lb capacity should comply with the four fork truck stability tests recommended by the American Industrial Truck Association, and that these tests will apply within two years from January, 1959. The meeting also discussed the need to unify regulations applying to industrial trucks when used on the public highway, and preliminary discussion took place regarding a common set of regulations applicable to all European countries. A measure of agreement was reached in regard to certain sizes of pneumatic tyres which are to be standardised. A draft standard relating to Pallet Trucks was ratified for onward transmission to the I.S.O. with an indication that the standard would apply to trucks suitable for operation with the standard range of I.S.O. pallets. Whilst dealing with standardisation the matter of controls and voltages also came under review. In the former case British Ministry of Supply recommendations would be followed so far as standard levers and knobs on industrial trucks were concerned, and in the latter four recommended voltages for battery powered electric trucks were agreed on the basis of 12V, 24V, 36V and 80V.

A proposal by the German delegation that a European Exhibition of Materials Handling Equipment should be staged is to be referred back to the German National Committee on the basis that its terms were too wide for the agenda for Section IV. With regard to a French request for an exchange of production statistics, it was agreed these would be forwarded by the British Industrial Truck Association based on Board of Trade and Government figures as they became available.

The meeting ended with the election of the Italian delegate M. Turrinelli as the President for the forthcoming year and the election of the Swiss delegate, M. Dreyer, as Vice-President. The next meeting is to be at Ostend from October 14 to 18, 1958.

# STAINLESS STEEL REACTOR VESSEL FOR ENRICO FERMI ATOMIC POWER STATION

Fig. 1—External machining of rotating plug assembly on "Betts" vertical boring mill

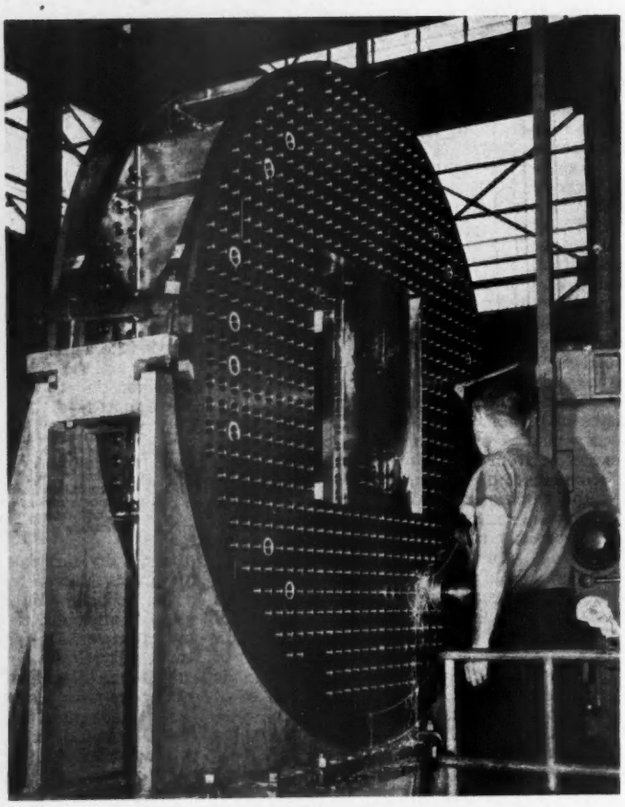


Fig. 2—Machining of holes in stainless steel support plate assembly on "Gilbert" horizontal boring mill

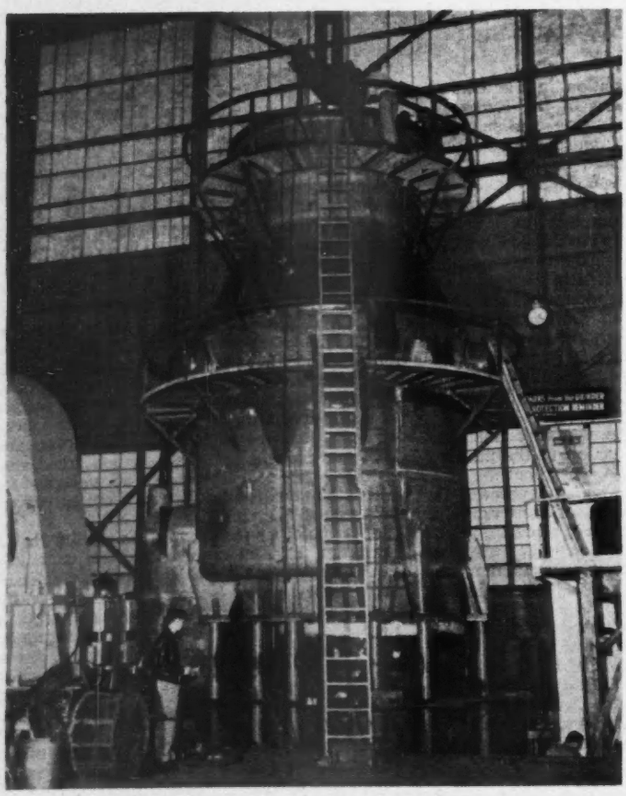


Fig. 3—Shop erection of completed A.P.D.A. reactor vessel using optical alignment methods

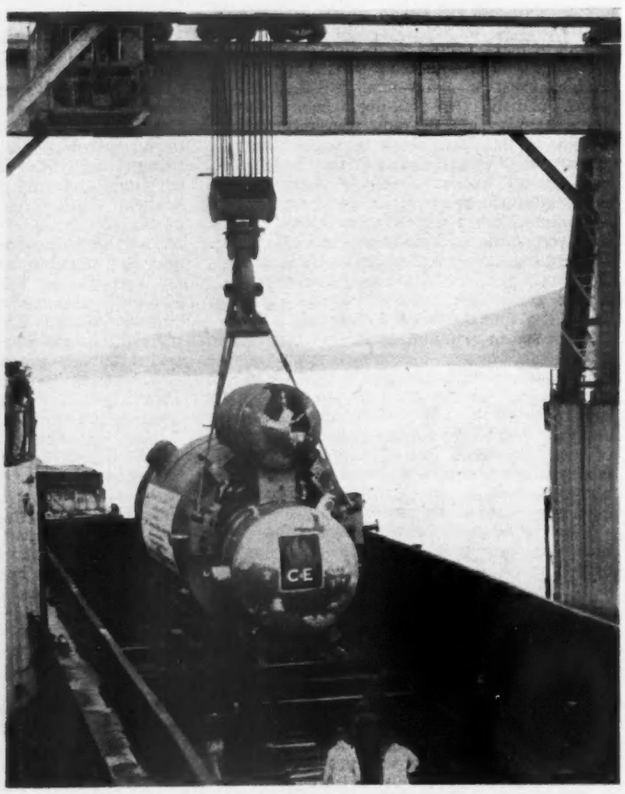



Fig. 4—Loading of reactor vessel on river barge by means of 250-ton crane at Chattanooga

# Stainless Steel Reactor Vessel for Enrico Fermi Atomic Power Station

BY OUR AMERICAN EDITOR

*A large stainless steel reactor vessel recently ended a 1600-mile barge-and-rail journey from Chattanooga, Tennessee, to the Enrico Fermi Atomic Power Station on Lake Erie, 7 miles north of Monroe and 30 miles south of Detroit. The vessel was built to basic designs by Atomic Power Development Associates, Incorporated (A.P.D.A.), the non-profit organisation responsible for the research, development and design relating to the Fermi breeder reactor project. It was detail-designed and constructed by Combustion Engineering, Incorporated, in Chattanooga, Tennessee.*

THE A.P.D.A. reactor vessel shown in the accompanying illustrations, is believed to be the most complex stainless steel pressure vessel of its size ever built. It is made up of four separate cylindrical vessels welded together. The four major components of the 36ft high reactor vessel are the lower vessel, the upper vessel, the conical transition section and plug container, and the transfer rotor container. The design and manufacture were greatly complicated by the eccentric relationships of these components and the severe thermal conditions and nuclear radiation anticipated in operation.

The lower reactor vessel, which is 9ft 6in in diameter, houses the baffling and thermal shielding necessary for protecting the vessel from radiation damage and thermal stresses. It also distributes the inlet coolant flow through the nuclear fuel, the plutonium breeder blanket, the control rods, and the shield. The lower reactor vessel contains the support plates which support and locate 673 8ft long 2½in square tubes containing the nuclear fuel, breeder blanket, and nuclear control and safety rods. These extend to a point just above the junction of the lower reactor vessel with the upper reactor vessel. The upper reactor vessel, which is 14ft 6½in in diameter, houses the fuel handling device, the hold-down plate, and the eight safety rods. The main sodium coolant discharge is situated in this section. The upper reactor vessel will be operated at approximately atmospheric pressure, with an inert gas atmosphere maintained above the sodium level.

The conical transition section and the plug container is a single unit welded to the upper reactor vessel. This section houses and supports the rotating plug, which in turn houses and supports the fuel handling device, the hold-down drive mechanism, and control and safety rod drive mechanisms. The transfer rotor container houses the transfer rotor which provides for lateral transfer of the fuel and blanket subassemblies to a position where they can be removed from the reactor vessel. It also provides the temporary decay storage for irradiated subassemblies immediately after removal from the reactor.

The reactor is supported by twelve flex plates which are attached to the bottom of the upper reactor vessel and bolted to foundation plates situated below the bottom head of the lower reactor vessel. These flex plates are 7ft 4½in long and are designed to allow for the thermal expansion of the vessel during operation while maintaining its correct horizontal position under all operating conditions. The flex plates will support a total operating weight of approximately 600 tons.

### Design of Vessel

The reactor vessel is designed for conditions of 50 lb per square inch gauge at 1000 deg. Fah. at the outlet of the upper reactor vessel, and 110 lb per square inch gauge inlet pressure at 650 deg. Fah. at the lower reactor vessel. Because of these low pressures it was possible to make use of a thin wall. The wall thicknesses were determined from the applicable requirements of the A.S.M.E. Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels. In most areas, the vessel wall is heavier than required by code standards because of the fabrication handling problem associated with a thin-walled vessel of such large diameter. The design considerations of this vessel were : pressure, steady-state temperature, temperature transients, internal weights and external reactions. Areas for which no specific design procedure is presented in the Code were investigated by advanced methods of stress analysis. Such areas include the support structure for the fuel and breeder blanket and the transition region between the upper and lower reactor vessels. The transition region is made additionally complex because the transfer rotor container is attached to this region.

The walls of the reactor vessel will be lined internally with many layers of concentric stainless steel shield plates ranging in thickness from ¼in to 1in. Their total thickness amounts to 4½in in the upper reactor vessel and 6in in the lower reactor vessel. Two circumferential rows of solid stainless steel bars, placed between the reactor core and adjacent to the lower reactor vessel shielding plates, provide additional shielding in this zone of intense radiation. The reactor vessel shielding has been provided for a two-fold purpose : primarily for the reduction of radiation effects on the vessel wall and external components which are within the primary plant shielding and, secondarily, to serve as a buffer zone to prevent a sudden change in sodium coolant temperature from being experienced by the vessel structure. Rapid temperature changes of the sodium coolant of as much as 300 deg. Fah. in one second can occur in the sodium leaving the reactor due to the rapidity with which the reactor can be shut down.

Liquid sodium, the coolant used to remove the heat created in the reactor, enters the lower reactor vessel head through three 14in diameter inlet nozzles. Each of these nozzles serves one-third of the lower head, and each section is separated from the other by a baffle plate. The inlet nozzle is designed with an eductor to induce flow between the lower head shielding plates. Sodium also enters the reactor system in the lower reactor vessel through three 6in diameter nozzles situated above the 14in nozzles which supply coolant through a low-pressure plenum to the plutonium breeder blanket radially surrounding the core. The sodium in the system flows upward through the fuel and the breeder blanket. Some of the low-pressure sodium is directed between the annuli of the lower and upper reactor vessel cylindrical shielding plates and between the deck shielding plates. The requirement for cooling this shielding posed many engineering problems in orificing the sodium flow from the lower reactor vessel low pressure inlet.

Twelve thermal shield plates were necessary to protect the upper reactor vessel, and eight thermal shield plates were necessary to protect the lower reactor vessel. The eccentrically shaped transition deck between the lower reactor vessel and the upper reactor vessel is protected by thirteen shield plates. Zones of discontinuity, such as nozzles, are protected by thermal shielding to prevent these structures from feeling the direct impact of sudden temperature changes imposed by transient operation of the reactor. The transfer rotor container will be cooled by the circulation of sodium from the lower reactor vessel through the transfer rotor container by means of four 1in diameter tubes connecting to the lower reactor vessel low-pressure inlet. The opening between the transfer rotor container and the upper reactor vessel is closed with an L-shaped cylindrical segment. This particular "trap-door" serves to prevent mixing of the sodium from the upper reactor vessel into the transfer rotor container when sudden temperature changes occur in the sodium due to transient

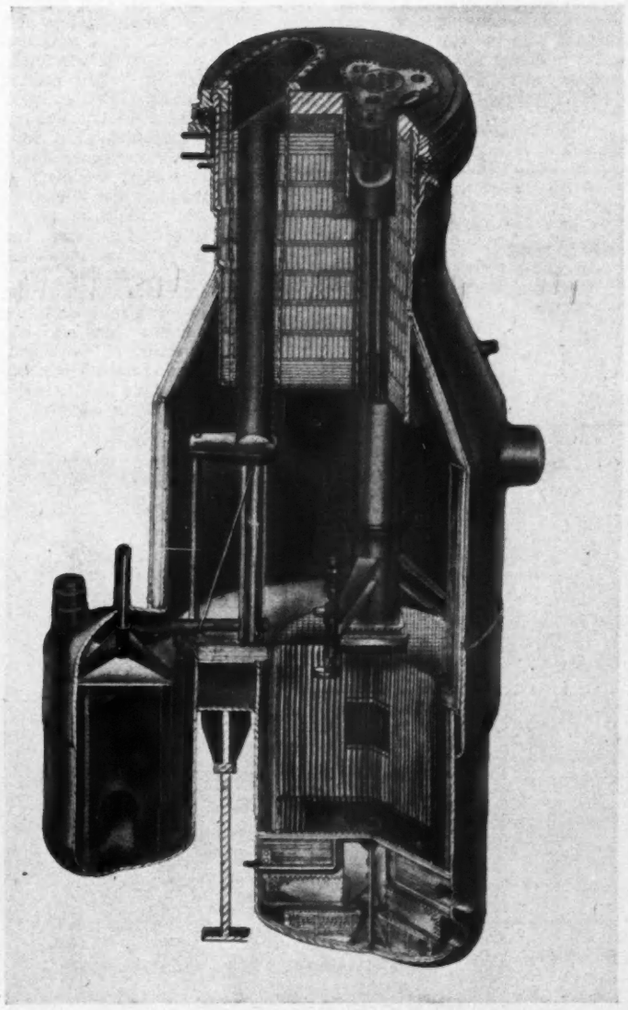


**Fig. 5—Artist's impression showing internal arrangement of A.P.D.A. reactor vessel**

operation of the reactor. Each shield plate in the vessel has internal heat generated by intense atomic radiation from the reactor. This heat must be removed by the sodium flowing in the annuli between the plates.

The rotating plug rests on a load-carrying ring which is supported on a double row of ball bearings resting on the plug container flange. The assembly of the ball bearings and races is such that at the re-fuelling temperature the centre lines of the balls will be as near parallel to the centre line of the reactor vessel as possible. At the re-fuelling temperature, the plug must be rotated so that the fuel and breeder blanket sub-assemblies can be removed and installed. This is accomplished by a combination of plug rotation and rotation of the offset fuel handling mechanism. At all other temperatures, the centre lines of the ball bearings are not co-axial and therefore the races which carry the ball bearings had to be designed to accommodate a mismatch while still providing four-point loading of the balls. The hydraulic action of the sodium flowing through the core would tend to lift the fuel from its support in the fuel support plate. The hold-down plate is used to exert the necessary downward force to prevent such an event from occurring. The hold-down column which drives the plate also serves as a support for the control and safety rods and extensions from these rods to the control and safety rod drive motors on top of the plug. This structure required special design attention to minimise the sodium pressure drop caused by the turning of the sodium flow and the frictional losses over the hold-down rods.

### Manufacture of Vessel

One of the original design objectives was to manufacture the safest vessel that could be built. This requirement complicated manufacturing operations which were performed with the aim of achieving the ultimate quality possible. Many of the procedures had no precedent in a stainless steel pressure vessel of this size. These problems were complicated due to the eccentricities of the various vessels that had to be assembled. There were many instances of precise machining and assembly in which the end results exceeded the initial hopes of the designers. The size and complex geometry of the vessel required the use of large and costly manufacturing facilities. Among these are a 15 MeV X-ray machine, a large high-temperature annealing furnace, a large sandblast facility, a 20ft vertical boring mill, numerous special horizontal boring mills and large weld positioning equipment. Because of the large size and thin walls, extreme care was necessary when handling vessel components and the completed vessel in order to prevent damage during manufacture. Special jigs and fixtures were designed to turn and position components on machines, to aid in the assembly of the vessel and to move large components without distortion.

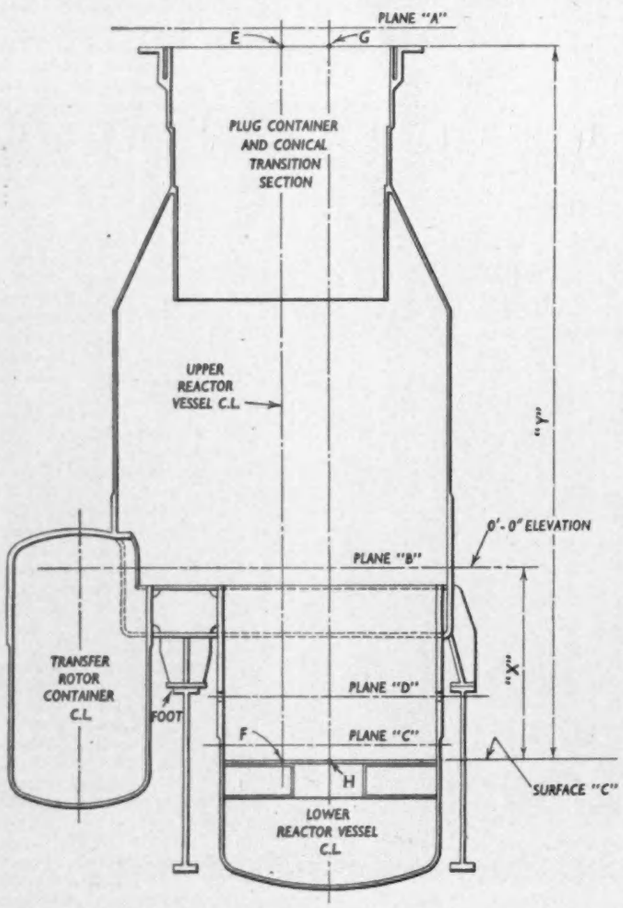
Stainless steel is a relatively difficult material to control during welding under ordinary circumstances. The construction of the A.P.D.A. reactor vessel involved the deposition of nearly a half mile of weld material in the full penetrant weld seams of the vessel and more than a mile of metal for the shielding, rotating plug and miscellaneous structure. Due to the complex configuration of the vessel components, it was necessary to use mirrors to do some of the welding in very confined quarters. Some areas were as small as 11in by 15in so that it was impossible for the welder to wear a conventional safety helmet, and in others welders were called upon to assume a doubled-up position to reach almost inaccessible spots. In some instances it was necessary to qualify welders each day before they began work in these cramped quarters. Major closure welds of the lower to the upper reactor vessel and the upper reactor vessel to the conical transition section required nearly two months on a seven-day week basis, including time for inspection and optical checks. In a structure the size of the A.P.D.A. vessel it was most important to avoid distortion by the careful control of the welding process. For the major closure welds it was the practice to have four welders working simultaneously, positioned to maintain the alignment and parallelism of the machined surfaces. The problem of predicting and controlling weld shrinkage and distortion involved not only the amount but also the direction of movement. Models and full scale sections were built to determine this in advance.

Some of the most difficult manufacturing operations involved the support plates for the reactor vessel. These support plates, which are spaced 14in apart and are made from 2in thick A.I.S.I. Type 347 stainless steel plate, are designed to support and locate fuel and breeder blanket sub-assemblies, control rods and a portion of the lower reactor vessel thermal shield plates. The centraf portion carrying the fuel sub-assemblies is a removable square section. The vertical alignment of the holes in the two support plates was specified to be held within ±15 seconds, which is equivalent to 0·0005in per inch deviation between the parallel plates. There are nearly 1000 holes in each support plate which are located from two central datum lines within a tolerance of ±0·005in. Each hole, approximately 2in in diameter, was machined to within 0·001in on the diameter. This was done on a 5in horizontal boring mill with special horizontal and vertical movement to do the entire job without moving the support plate from the machine. Some idea of the accuracy of the machining may be derived from the fact that it was necessary to compensate for the effect of the temperature differential on the vernier scales of the machine. The horizontal scale was located at floor level, while the vertical scale was exposed to room temperature air at a higher level. Compensation also had to be made for the differential expansion of the carbon steel scales and the stainless steel support plate. As little as 5 deg. to 10 deg. Fah. temperature difference was enough to cause the support plate to get out of tolerance. The machining speeds had to be carefully controlled to avoid the work hardening of the support plate. The inspection of this machining operation was also a time-consuming operation. The optical observations, carried out in the clean room at a constant temperature of 68 deg. Fah., required two weeks.

### Optical Alignment

The accuracies required in the assembly and alignment of the A.P.D.A. vessel would have been very difficult, if not impossible, without the use of optical tooling methods and equipment. For example, dimension "*X*" in the accompanying illustration called for plus or minus $\frac{1}{16}$in in a distance of 96$\frac{1}{2}$in while dimension "*Y*" called for plus or minus $\frac{1}{8}$in in a distance of 355$\frac{1}{2}$in. The final examination of the dimension "*X*" proved it to be within $^1/_{32}$in or a deviation of only one part in 3088. Dimension "*Y*" was found to be within $\frac{1}{16}$in, a deviation of only one part in 5692. The above was accomplished while maintaining a parallelism of surfaces approximately 10ft in diameter.

In conducting the optical alignment survey, a series of parallel horizontal planes were established by the use of a tilting level equipped with



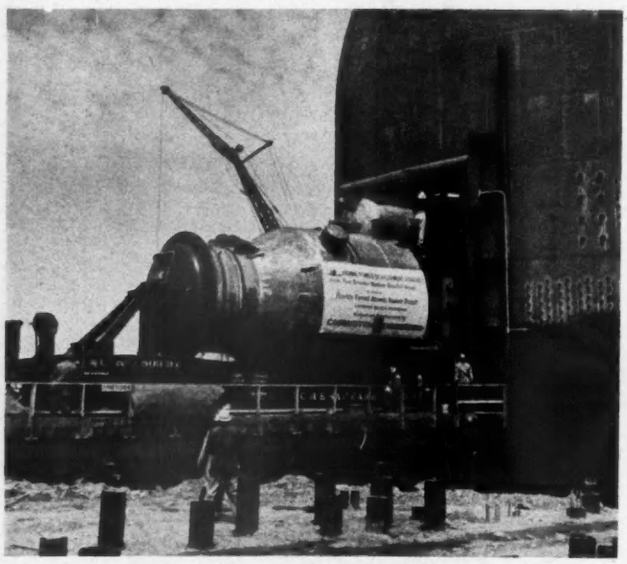



Fig. 6—(Left) Optical alignment survey of A.P.D.A. reactor vessel. Fig. 7—(Right) Entry of A.P.D.A. reactor vessel into 72ft high containment building at site of Enrico Fermi atomic power station

an optical micrometer and an alignment telescope with a stride level. To start with, the intermediate section of the vessel with the twelve external supports and the transfer rotor container was set up on legs so that the previously established plane "*B*" at elevation 0ft 0in was horizontal. Next, the lower vessel was positioned in relation to centre lines and the surface "*C*" was levelled. Last, the upper vessel was positioned and the flange levelled in relation to the 0ft 0in plane. With the previously mentioned optical instruments, planes "*A*," "*B*," "*C*," and "*D*" were established parallel to each other within two seconds of arc (about 0·001in in 9ft). From these established imaginary planes the elevation of some 60 points on the flange was determined in relation to plane "*A*" and some 28 points on the ledger support ring to plane "*C*." The distances were obtained with an optical tooling scale which could be easily read to plus or minus 0·001in. The optical alignment check of the upper reactor vessel to the lower reactor vessel, with eccentric centres of 24·237in, was accomplished by projecting a vertical line from the centre of the upper reactor vessel (point *E*) to an optical target in a precision-bored bar in the lower reactor vessel (point *F*). A vertical line from point *G* to point *H* was projected in a similar manner. The accuracy of the two projected vertical lines was about two seconds of arc and the optical targets could be read to plus or minus 0·001in. The distance between the horizontal parallel planes was established with a standard 50ft steel tape supported above plane "*A*" and hanging plumb inside the vessel. The tape could be easily read to plus or minus 0·005in.

### Shipment of Vessel

The shipment of the reactor vessel created some of the most difficult moving problems in industrial history. Planning for the shipment began in September, 1955, immediately after the order was placed with the manufacturer. Two and a half years later, on April 10, 1958, the completed reactor vessel was moved by a flat wagon from the "Nuclear Bay" of the Combustion Engineering shops at Chattanooga to the manufacturer's dock on the Tennessee River, a distance of half a mile. There, a 250-ton crane raised the reactor vessel from the wagon and set it aboard a river barge. The barge proceeded 928 miles along the Tennessee and Ohio rivers. At the Miami Fort Station of the Cincinnati Gas and Electric Company at Columbia Park, Ohio, near Cincinnati, the 80-ton vessel was carefully hoisted from the barge. A crane lifted the reactor vessel into position on a wagon of the Chesapeake and Ohio Railroad which had been specially modified to carry the vessel. Five railways handled the final 670-mile rail segment of the journey: Baltimore and Ohio; New York Central; Nickel Plate; Chesapeake and Ohio; and Detroit, Toledo and Shoreline. The speed was 10 to 15 miles per hour—slower in areas of close clearance. The clearance problems in the rail portion of the trip were acute. Bridge, trestle, and underpass clearances had been previously checked all along the route. Tree limbs, wires and telephone cables were cleared. At Delaware, Indiana, a highway bridge over the Baltimore and Ohio tracks was raised and widened.

At Benton Harbour, Michigan, where there are three river bridges, "shims" were used on the rails to tilt the cargo clear of side structures. At other points of very close clearance the train was stopped and the flat wagon carrying the vessel was pulled by winch and cable an inch at a time. To provide maximum insurance against unforeseeable problems or damage, the wagon immediately preceding the vessel-carrying wagon served as a "pilot" car. On this pilot car, a "mock-up" with the same maximum external dimensions as the reactor vessel was mounted. Thus, any threat of damage to the cargo proper could be detected in advance.

The reactor vessel is destined for installation in the 72ft high gas-tight reactor containment building at the Enrico Fermi site. The Fermi reactor will be the only privately-financed reactor in the United States having the ability to make more atomic fuel than it uses, while at the same time producing heat-energy for steam-electric power generation. Three separate organisations, together with the U.S. Atomic Energy Commission, are participants in the Enrico Fermi project. Besides the Atomic Power Development Associates, these are the Power Reactor Development Company (P.R.D.C.) and the Detroit Edison Company. A.P.D.A. is responsible for research, development and the design of the nuclear portion of the atomic plant, and will also conduct exhaustive tests to confirm all the safety characteristics of the reactor. P.R.D.C. is financing and building the reactor facility, which it will own and operate. The third participant, Detroit Edison, is building the conventional turbo-generator section of the plant and will operate it on steam purchased from P.R.D.C. The power generated will be fed into the firm's electrical system and used throughout the south-eastern Michigan grid area. The Detroit Edison Company is a member of both A.P.D.A. and P.R.D.C., and its president, Walker L. Cisler, also is president of these two groups.

Following the installation of the reactor vessel and related equipment at the Fermi site, A.P.D.A. will test-operate the reactor at design heat and pressure conditions but without the use of nuclear fuel, for about one year beginning in February, 1959. Nuclear fuels will not be used until the entire installation has been thoroughly tested to meet the rigid safety and health requirements of the A.E.C. The issuing of an A.E.C. operating licence depends upon these requirements being met. The Enrico Fermi Atomic Power Plant is expected to be ready for nuclear operation in 1960. After several months of initial nuclear operation, it is expected to generate 100MW of electricity.

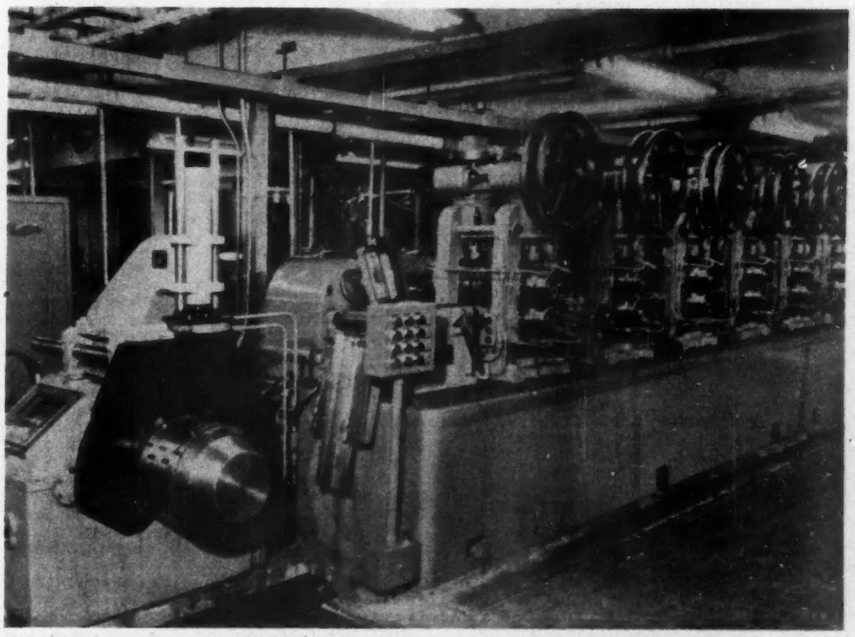
## Eight-Stand Tandem Cold Reduction Mill

The development of an interesting high-speed cold reduction mill for the continuous rolling of thin strip has been announced by the Loma Machine Manufacturing Company of New York. As shown in the accompanying illustration, the new machine employs an exceptionally compact layout of eight individual 6in diameter by 8in face two-high mill stands mounted with their respective drives on one common base. Each set of rolls is driven by a 40 h.p. variable speed d.c. motor through a combination gear reducer and pinion stand and a pair of universal joint spindles. The rolls are made of forged alloy steel and are hardened to 100 Shore Scleroscope. Tungsten carbide sleeves are mounted on several of the rolls to obtain long operating life and highest surface finish. The roll necks are mounted in super-precision oil film bearings which are continuously lubricated by a closed oil circulating system. Exact roll adjustment is facilitated by twin-hand-wheel wormdrive screwdowns on each stand. For strip cooling purposes, the entire mill is flooded with soluble oil from a central circulating system. Several complete mill stands are furnished as spares for roll maintenance and are exchanged by overhead crane in a matter of twenty minutes.

The machine is normally fed with annealed re-roll stock ranging from 0·072in to 0·093in gauge. This material is either purchased from the large producing mills or, in the case of aluminium alloys, may also be manufactured at site by means of a continuous strip-casting machine combined with a hot rolling mill. At the entry side of the tandem mill, 16in I.D. by 40in O.D. coils are paid off into the No. 1 stand from a coil box equipped with a back-tension bridle. During its passage through the mill, the strip is positively guided so that the entire installation is completely self-threading. Vertical edge control stands are provided at four points between horizontal stands.

Upon leaving the final mill stand, the strip is dried by a wiper bridle, is continuously measured by a "flying mike" thickness gauge and is coiled by the winding reel. The reel is equipped with a 16in diameter collapsible drum, a belt wrapper mounted in a pit, a coil stripper and a hold-down device. All these auxiliaries are hydraulically actuated and are electronically controlled to obtain automatic cycling. The reel is driven by a 15 h.p. variable speed d.c. motor which has magnetic amplifier control to facilitate constant tension winding. The entire electrical mill drive operates on the adjustable voltage system with controlled acceleration and deceleration and has special provision to maintain constant strip tension between stands.

The mill illustrated has been installed by a leading American manufacturer of venetian blinds and awnings and is used to process low carbon steel and aluminium alloys to a finishing gauge of 0·006in in widths from 2in to 6in and at output speeds up to 1000ft per minute. Its heavy duty, high-precision design allows the mill to take total reductions of 95 per cent while maintaining tolerances as close as 5 per cent of thickness. Such accurate performance coupled with the high output capacity and relatively low cost of the mill make it a most useful tool for the custom-processing of specialty strip. Requiring only one operator and a helper, the machine makes it economical for many consumers of narrow strip to "roll it yourself" with consequent savings in raw material costs.



**Eight-stand tandem 6in × 8in two-high cold strip reduction mill with winding reel**

# Personal and Business

## Appointments

MR. J. C. DRIVER has been appointed chief inspector of West Instrument, Ltd.

MR. ERIC LORAM has been appointed general sales manager of Small and Parkes, Ltd.

MR. JOHN CRUISE has been appointed sales manager of the " Salterpak " division of Geo. Salter and Co., Ltd.

THE WALTER KIDDE COMPANY, Ltd., has announced the appointment of Mr. Andrew Smith as managing director.

MR. F. FOSTER, A.M.I.E.E., has been appointed managing director of Crompton Parkinson (Stud Welding), Ltd.

MR. R. M. I. HOBILL has been appointed manager of the transformer department of Ferranti, Ltd., in succession to Mr. J. E. L. Robinson.

HAWKER SIDDELEY GROUP, Ltd., has announced that Sir Roy Dobson has been appointed managing director of the company in succession to Sir Frank Spriggs.

MR. A. F. JOPLING, a director of Blackburn and General Aircraft, Ltd., has been appointed a director of Blackburn (Dumbarton), Ltd., and Thomas Green and Son, Ltd.

ELECTROFLO METERS COMPANY, Ltd., announces that Mr. N. Maggs has joined its systems engineering division as contracts engineer, and Mr. F. Cheventre as outside representative in the London and southern England areas.

SHARPLES CENTRIFUGES, Ltd., has announced that Mr. M. E. O'K. Trowbridge has been appointed managing director. Mr. J. J. Serrell has been appointed a director.

THE PLESSEY COMPANY, Ltd., announces that Mr. Andrew M. Brown has been appointed executive director with special responsibilities as personnel co-ordinator. He will take up his duties on July 7.

BRISTOL SIDDELEY ENGINES, Ltd., Ormonde House, 26/27, St. James's Street, London, S.W.1, a new company formed jointly by Bristol Aero-Engines, Ltd., and Armstrong Siddeley Motors, has appointed Sir Mark Norman, Bt., as company secretary.

WILLIAM DOXFORD AND SONS, Ltd., announces that Mr. Robert Atkinson, managing director of Hamworthy Engineering, Ltd., has been appointed managing director of its subsidiary company, William Doxford and Sons (Engineers), Ltd., and will take up his duties on September 1.

THE RUBEROID COMPANY, Ltd., has announced that Mr. D. L. Irwin, Snr., has retired as managing director and has been succeeded by Mr. D. L. Irwin, Jnr., and Mr. G. D. L. Goslett as joint managing directors. Mr. Irwin, Snr., retains his seat on the board as consultant director and his appointment as chairman. Sir Richard Yeabsley has been appointed deputy chairman.

## Business Announcements

BRITISH AND COMMONWEALTH SHIPPING COMPANY, Ltd., states that Mr. Douglas Swanson has retired from the Union-Castle Line.

CROFTS ENGINEERS (HOLDINGS), Ltd., has announced the opening of a subsidiary company, Crofts U.S.A., Ltd., Chicago, to deal with trading activities in the U.S.A.

PERRY AND CO. (Holdings), Ltd., has announced the formation of Perry Industries S.A., 26, Rue de Bordeaux, Brussels, 6. Mr. S. V. Delo has been appointed managing director.

RUSTON-BUCYRUS, Ltd., Lincoln, announces that it is represented in South-West England by Mr. F. B. Lawrence, 38, Stoke Road, Taunton, and in South Wales by Mr. J. N. Revill, 31, Ashgrove, Whitchurch, Cardiff.

ROLLS-ROYCE, Ltd., has set up a subsidiary company in Brazil to manage an overhaul and spares depot for their turbine and diesel engines. Present firm orders for civil airliners will result in nearly 150 R.-R. turbines being in service in South America by 1960, principally " Dart " propeller turbines in " Viscount " and Fairchild-built " F.27 " machines.

THE ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., Crown House, Aldwych, London, W.C.2, states that the turbine-generator division, managed by Metropolitan-Vickers Electrical Company, Ltd., and the heavy plant division, managed by the British Thomson-Houston Company, Ltd., became operative on July 1. The following management appointments have been made :—Heavy Plant Division : Mr. L. Drucquer, divisional ganeral manager ; Mr. L. D. Anscombe, divisional chief engineer ; Mr. C. W. Furniss, divisional manufacturing manager ; Mr. R. M. Grant, divisional commercial manager ; Mr. N. R. D. Gurney, divisional executive (Manchester). Turbine-Generator Division : Mr. R. J. Cochran, divisional general manager and divisional commercial manager ; Dr. W. H. Darlington, divisional chief mechanical engineer ; Mr. W. N. Kilner, divisional chief electrical engineer; Mr. R. R. Whyte, divisional manufacturing manager (Trafford Park) ; Mr. D. R. S. Turner, divisional manufacturing manager (Larne) ; Mr. J. G. Boddy, divisional executive (Rugby).

## Contracts

RUSTON AND HORNSBY, Ltd., is to export to Russia a 1000kW Mark TA turbo-generator mounted on a special rail wagon to provide a mobile electric generating plant. This is, we are informed, the first instance of a British industrial gas turbine being used in Russia, although, of course, British aero engines have been widely used and adapted in that country.

HUMPHREYS AND GLASGOW (CANADA), Ltd., has received a contract for what is believed will be the world's first thorium recovery plant. This is to be built near the Algom Quirke mine at Blind River, 5 miles north of Elliot Lake, Canada. The company will be responsible for the design and construction of the plant and for the installation of the special equipment needed. A process evolved by Dow Chemicals in smaller pilot plants will be adapted for treating the thorium concentrates, thorium sulphates and thorium oxide. It is expected that operation will be under way by January, 1959, with the plant working at capacity by May, 1959.

## Miscellanea

PLANT AT HOSCAR SEWAGE PURIFICATION WORKS.—In our issue of June 13 last, we published an article with the above title, which concluded with a description of the heat exchange systems associated with the dual fuel engines installed at Hoscar. Sludge is heated by the engine cooling water, as shown in the diagram on page 899. At the foot of the first column of this page, the temperatures given are not correct. At the inlet to the engines, the cooling water temperature is in fact at about 140 deg. Fah., and at the outlet, before it passes through the exhaust gas heater, its temperature is about 150 deg. Fah.

MOTOR VEHICLE STATISTICS.—The May, 1958, *Monthly Statistical Review* of the Society of Motor Manufacturers and Traders, Ltd., shows that in 1957 Great Britain was the second largest exporting country of both cars and commercial vehicles, exporting 426,272 cars against 515,882 by Western Germany and 123,283 commercial vehicles against 193,813 by United States of America. The commercial vehicles were divided quite evenly over the continents at roughly 20,000 to Europe, America, Asia and Oceania, with Africa taking 37,000 ; the cars, however, varied widely, 100,000 going to Europe and 143,000 to America, in both of which markets Western Germany is the largest exporter.

TRIAL CABLE LAID IN COOK STRAIT.—We learn that the length of submarine power cable manufactured by the B.I.C.C. group of companies for trials in the Cook Strait was laid on May 31, under the control of engineers from British Insulated Callender's Construction Company, Ltd. The trial length was laid by the cable-ship N.Z.G.S. " Matai," seawards from Oteranga Bay, which is on the North Island shore of Cook Strait south of Cape Terawhiti. The cable is anchored and will be allowed to remain on the sea-bed for as long as possible. This single-core pre-impregnated high-pressure gas-filled cable is designed for a direct current voltage of 250kV, has an overall diameter of 5in and is half-a-mile long.

LARGE HELICOPTER AIRBORNE.—Last month there took place the first flight of this country's largest helicopter, the prototype Westland " Westminster." The construction of the " Westminster " started only eight months ago, and pre-flight ground trials took only twelve days : this celerity is attributable to the derivation of the machine from the Sikorsky " S.56," from which it differs in having gas turbine engines, a pair of Napier " Eland " fixed-shaft turbines driving from the exhaust end. The fuselage is quite different from that of the earlier machines, the engines being mounted on top of it : the prototype has a steel tube framework and from it will be evolved a " flying crane " utility version, to be followed by a cabin machine to carry forty-five passengers. The aircraft weighs nearly 14 tons, has a 70ft long fuselage, and should have a range of 400 miles and a cruising speed of 150 m.p.h.

ANALOGUE COMPUTER FOR REACTOR PROBLEMS.—The makers inform us that, less than a year after the original plans were made to design and manufacture it, the first EMIAC II general-purpose analogue computer has been delivered to the Hawker Siddeley Nuclear Power Company at Slough. We understand that this computer has now gone into full-scale production at the Hayes factory of E.M.I. Electronics, Ltd. It is stated that the versatility of the computer enables a single module, or a combination of several, to be used, according to the complexity of the problem to be solved. The various computer units are interchangeable in a standard rack. The computer uses time division, or mark space ratio multipliers. This system has been developed by E.M.I. to a point where they consider that it compares favourably in accuracy with a conventional servo-driven potentiometer multiplier.

MAGNETIC CHUCKS.—A magnetic chuck, particularly intended for use on production grinding machines, where maximum table loading of relatively small components is required, is now being made by James Neill and Co. (Sheffield), Ltd., Sheffield, 11. These fine pole permanent magnet chucks have a high effective magnetic area on their work-holding surfaces, and the model at present available has a working surface of 18in by 6in. It is understood that similar chucks will shortly be available for table sizes of 24in by 8in as well as for 10in and 12in wide tables in any multiple lengths of 18in. On this design of chuck the " inner " poles extend from edge to edge with a castellated arrangement of the poles providing the major holding area in the centre. The " outer " poles are linked together, thus enabling magnetic flux from all magnets to be fed to a single workpiece placed anywhere on the chuck surface.

HEAVY-DUTY LIFTING MAGNET.—A heavy-duty lifting magnet, 55in long by 48in wide, now being made by Rapid Magnetic Machines, Ltd., of Lombard Street, Birmingham, 12, is designed for handling material from haphazardly stacked stockpiles. It is designed to overcome a disadvantage of the more general circular pattern magnets, in which the penetrative qualities are disposed only at the centre pole or over about one-third of the diameter of the magnet. In the new rectangular magnet the powerful impinging field, ranging over the entire length of the operating face, is stated to give a substantial increase in payload of approximately two and a half times that of a comparable circular pattern. In one application the 55in long by 48in wide magnet is successfully handling 8-ton lifts of loose 2¼in square billets, in the railway sidings of a large works in Manchester. If required, specially constructed motorised spreader beams can be incorporated to enable a load to be rotated through 90 deg.

PRESS BRAKES.—An interesting film on press brakes, produced by the Bronx Engineering Company, Ltd., Lye, Worcs, and W. E. Norton (Machine Tools), Ltd., Grosvenor Gardens House, London, S.W.1, was shown recently to an invited audience in London. This film graphically describes the versatility of " Bronx " presses when fitted with standard tooling for the production of all kinds of sheet metal and light plate components. It was taken in the press shops of a number of firms engaged in both long run and batch production of parts, and includes interesting examples of many multiple folding and forming operations not generally associated with press brakes. The film emphasises how standard tooling can be supplemented by special tooling to widen the scope of press brakes, and how economies in manpower and plant can be achieved by two or more men carrying out a sequence of operations on a single machine. We understand that copies of the film are now available for showing at firms which are users of press brakes or anticipate installing press equipment.

INDUSTRIAL FILMS.—Two new films entitled " Phoenix City " and " All Aboard," both in Eastman colour, were shown by Bowaters Sales Company, Ltd., in London last month. The war-damaged city of Coventry was chosen as the setting for the first of these films, " Phoenix City," which illustrates some of the many uses of Bowater insulation board and metal fixings systems. The film runs for nineteen minutes. " All Aboard," an animated cartoon film, which runs for ten minutes, describes the raw materials, the manufacturing processes, the types of board available and their applications both in building and in industry. Both films are available on loan in 35mm and 16mm sizes. A film of press brake tool applications has been produced by the Bronx Engineering Company, Ltd. It illustrates the wide variety of work which can be carried out by means of a press brake and explains how simple types of tools can be used to form up complicated sections. The film runs for twenty minutes and is available on loan in 16mm size in a number of different languages.

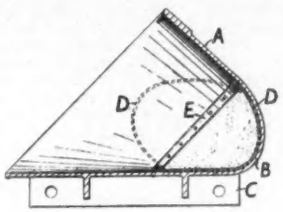
# British Patent Specifications

*When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.*

## CONTRACTORS' PLANT

**795,931.** September 9, 1955.—BUCKETS FOR DREDGING AND EXCAVATING APPARATUS, Wilhelm Kalis, a subject of the Queen of the Netherlands, and Hermanus Wouter Kalis, a subject of the Queen of Great Britain, both of 14, Dartmouth Street, London, S.W.1.

As shown in the drawing, the dredging bucket *A* is of any suitable scoop-like shape, having a closed bottom *B* and means *C* whereby it may be attached to an endless chain in a dredging apparatus. A flexible lining *D* of sheet rubber or other suitable material is disposed within the bucket to fit reasonably closely



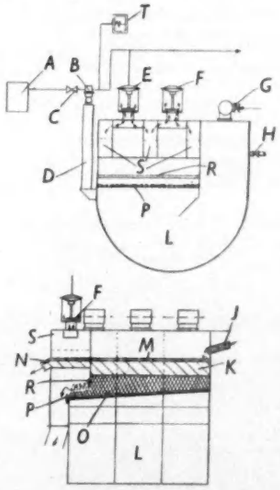

No. 795,931

to the inner surfaces of the bottom *B* and the lower parts of the walls of the bucket. At its free edge the lining *D* is secured to these walls (as shown) by a steel clamping strip *E* held by nuts on threaded studs welded on the inner surface of the bucket. In the portion of the bucket covered by the lining there are formed relatively small air-inlet apertures. When the bucket is inverted to discharge a load of cohesive material, the lining *D* is free to move away from the bottom and the dotted lines indicate the position assumed by the lining when it is completely turned inside-out. It is readily pushed back into its original position by the material entering the bucket as it scoops up another load because the lining cannot overhang the edges of the bucket at the mouth.—*June* 4, 1958.

## MINING ENGINEERING

**796,409.** September 17, 1954.—THE CONTROL OF COAL-WASHING APPARATUS, The Automatic Coal Cleaning Company, Ltd., 68, Lowther Street, Carlisle, England. (*Inventors: Walter May Wallace and James Donald Menzies.*)

The invention provides a system for controlling coal washboxes, comprising a number of fluid-operated valves for regulating the removal of discard from a washbox, a governor responsive to the quantity of discard material in the box and a pilot valve for the automatic control of the supply of fluid for



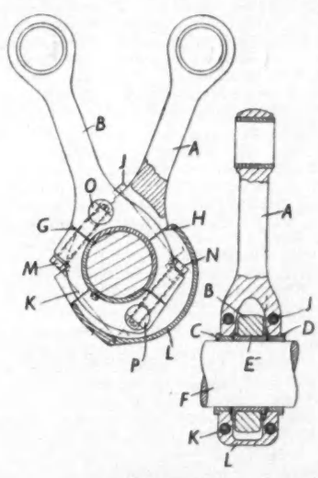

No. 796,409

operating the regulating valves. The governor is connected to the pilot valve so that the indications imparted by the governor control the pressure of the fluid supply for operating the regulating valves. In this way a large number of regulating valves can be operated. Referring to the drawing, air under pressure from *A* is fed to a pilot valve *B* of the kind described in Specification No. 722,993 through a throttle valve *C*. A governor *D* responsive to conditions in the washbox is connected to the pilot valve *B* through a cam or diaphragm, to control the pressure of air supplied from the pilot valve to discard regulating valves *E*, *F*, &c., situated in the discharge compartment and which control only the flow of air between the compartment and the atmosphere. The coal washing box is operated by air admitted through a valve *G*. Water is supplied at *H*. The washbox is fed with raw coal at *J*, forming a bed *K* which is separated by pulsations of water in the spaces *L* into an upper layer *M* of coal, which is discharged at *N*, and a lower layer *O* of shale which is discharged between gates *P* and *R*. The valves *E* and *F* control the air outlet from the air chamber *S* at the discharge side of the box to atmosphere. When the valves *E* and *F* are closed, pulsations of water between the shale discharge gates *P* and *R* are suppressed and the discharge of shale is stopped. If the depth of the shale layer *O* increases, the governor *D* allows the valves *E* and *F* to open, and as air can then pass in and out of the air chamber *S*, the water can pulsate and shale is then discharged. The rate of discharge of shale, for a given setting of the gates *P* and *R* depends on the degree of opening of the valves *E* and *F*. The governor *D* responds to the thickness of the shale layer *O* and actuates the pilot valve *B* so as to cause the rate of discharge of shale to be increased when the thickness of the shale layer increases and vice versa, with the object of keeping the thickness of the shale layer as nearly as possible constant. A recorder *T* records fluctuations in the pressure of the controlling air supplied to the valves *E*, *F*, &c., and may be calibrated in units indicating the degree of valve opening, tonnage of material extracted, or any other quantity which is a function of the degree of valve opening.—*June* 11, 1958.

## INTERNAL COMBUSTION ENGINES

**796,473.** October 2, 1956.—HIGH-SPEED "V" ENGINES, The Maschinenfabrik Augsburgnurnberg A.G., Stadtbachstrasse 7, 13b, Augsburg 2, Germany.

The invention is especially concerned with high-speed "V" engines, of the kind having two connecting rods, connected to a common crank pin, one of the connecting rods being forked at the crank pin end to surround the corresponding end of the other or inner connecting rod. The invention provides a construction in which the connecting rods are respectively mounted on independent two-part bearing bushes which are in turn mounted on the



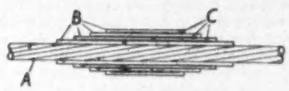

No. 796,473

crank pin. In it the bearing caps provided for the forked ends of the outer connecting rod are integrally connected by a reinforcing bridge extending over the whole periphery of the caps. This arrangement facilitates generally satisfactory lubrication of all lubricating points, and simplifies manufacture by the use of bearing bushes which are lined on only one side. The weight of the forked rod can also be substantially reduced. Referring to the drawing, the two connecting rods *A* and *B* are shown mounted on independent two-part bushes *C*, *D* and *E*, the bushes being in turn mounted on crank pin *F*. The connecting rod *A* is forked at its lower end to embrace the inner connecting rod *B*. Each rod has joint lines inclined with respect to the rod axis, as indicated at *G* and *H*, and the surfaces where the rod shanks contact the bearing caps can be provided with serrations as shown. For reinforcing purposes, the bottom bearing caps of the forked connecting rod are connected together by a bridge *L* which extends over the whole bearing cap. The shank and the cap of the inner connecting rod are connected by bolts *M* and *N* which respectively engage in corresponding screw threaded bores in pin-like members *O* and *P* inserted in apertures on opposite sides of the crank pin and parallel to the axis, the pins being positioned respectively in the shank and bearing cap. As a result of this measure, the forked connecting rod can be kept to small dimensions and assembly of the inner rod greatly facilitated whilst at the same time the strength of the rod is increased, since the notch effect caused by the threading cannot be effective in the connecting rod itself.—*June* 11, 1958.

## ELECTRICAL ENGINEERING

**796,241.** April 28, 1956.—ELECTRIC INSULATORS FOR OVERHEAD LINES, George Osborne McLean, "Four Winds," Station Road, Nailsea, Somerset.

The invention relates to the insulating of extra high voltage overhead conductors in the field by applying the technique of the electrical condenser, also known as capacitor, at each supporting structure. The object of the invention is to eliminate the high stresses on the insulating material at supporting structures of high voltage lines, and to allow some flexibility to the conductors at points of support. The upper view of the drawing is a sectional view of the bare conductor *A* at the locality of the formed insulator. One method of achieving this formation is by lapping round the conductor for a length and to a thickness determined by the voltage gradient

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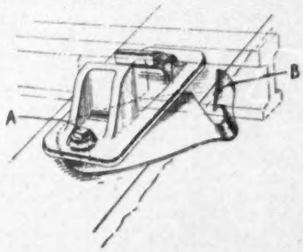
between conductor and supporting structure, a thin dielectric tape *B* of plastic material such as polythene, which retains its flexibility during and after lapping. For a shorter length but symmetrical about the vertical centre line of the dielectric cylindrical shape, is now wrapped a thin metal foil *C* or a metallic or graphite paste is applied. Successive layers of the dielectric flexible tape and metallic foil or paste are applied as shown until the total number of designed electrical steps have been made and the outside diameter and length of the final dielectric layer have been achieved. The whole insulator is then sprayed or brushed with varnish, hard setting plastic or silicone rubber to ensure a weather-resisting skin. An alternative method of forming the shape of the insulator is to wind a continuous sheet of the plastic dielectric material on to the conductor. With either method, a suitable machine can be used for wrapping and regulating the tension.—*June* 11, 1958.

## RAILWAY ENGINEERING

**796,340.** April 7, 1955.—SOLE PAD FOR RAIL CHAIRS, James Walker and Co., Ltd., "Lion" Works, Woking, Surrey, England. (*Inventor: Robert Hacking Hargreaves.*)

The invention relates to an insulating sole pad which when applied to a laid track may be positioned beneath a chair without having to dismantle the track. Broadly, the invention consists of a sole pad having a cut or slot extending from each holding-down bolt hole to the edge of the pad to permit the




No. 796,340

pad to be inserted or removed from its norma position between the chair and the sleeper by edgewise movement relative to the bolts. Preferably the body of the pad is flat and thin and to avoid weakening unduly the body of the pad it is preferred to break the continuity between each hole and the edge of the pad by a knife-cut. A slot may be made for this purpose without departing from the scope of the claims. The pad consists preferably of a flat, thin sheet composed of selected granulated cork, screened within certain limits, bonded by natural or synthetic rubbers or plastic materials. To position the pad beneath a rail chair, the holding-down bolts are slackened. A length of rail with its chairs is then

levered up and a pad, is placed beneath each chair, as shown in the drawing. This is effected by first pushing the narrow edge under the chair and causing the adjacent bolt to pass through the cut and into the bolt hole *A*. The pad is then swung around to cause the other bolt to pass through the cut *B* and enter the bolt hole. When the pads are in position the holding-down bolts are screwed home. To remove the pad for replacement purposes, the above procedure, after the holding-down bolts have been slackened back, is reversed. If will, of course, be understood that when laying a new track or relaying an old track the pads may be placed in position before the chairs are laid or with the chairs.—*June* 11, 1958.

## British Standards Institution

*All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.*

### WHITEHEART MALLEABLE IRON CASTINGS

No. 309 : 1958. Price 4s. Two grades of Whiteheart malleable iron castings (W22/4 and W24/8) form the subject of this revision of the 1947 edition of B.S. 309. It states that the chemical composition of the metal of the castings is considered to be of less importance than the mechanical properties. In consequence, compliance with the requirements of the specified tests is to be regarded as the main criterion of the materials " suitability for purpose."

The provision and heat-treatment of two sizes of test bar are specified, as are tensile test and a bend test ; provision is made for additional tests to be undertaken by arrangement with the manufacturer. Alternative dimensions for the tensile test bars which are given are based on practice in several other countries, and they have been included in order to gain experience with them in the United Kingdom, and to facilitate the exchange of information with other countries.

### GAS METER UNIONS AND ADAPTORS

No. 746 : 1958. Price 5s. The main changes embodied in this revised standard are the inclusion of requirements for unions of 2in nominal size, and of tables of dimensions for adaptors and adaptor washers. Slight alterations have also been made to the limits for screw threads, but they will not affect interchangeability between parts produced according to the 1937 edition of the standard. The publication specifies materials and screw threads and includes ten dimensional tables relating to bosses, nuts, liners, adaptors and washers. Two appendices deal with " Nominal Sizes " and " Method of Test for the Flexibility of Rubber Material."

### NON-FLUORESCENT MAGNETIC FLAW DETECTION INKS FOR FINISHED MACHINED AIRCRAFT PARTS

No. M.27 : 1958. Price 4s. This standard specifies the requirements necessary for inks suitable for use on aircraft parts for which magnetic flaw detection is a design requirement. It defines the composition of the ink and specifies the materials to be used in its manufacture. There are requirements for inspection of the ink and for its marking. Tests deal with determination of solid content, functioning and corrosion.

### METHODS OF TESTING VULCANISED RUBBER

No. 903. Part A5 : 1958, " Determination of Tension Set." Price 4s. This publication replaces Part 16 of the 1950 edition of B.S. 903, and its technical content is virtually unaltered. Apart from containing definitions and a summary and explanatory note covering the method of test, the document gives details of the test piece, apparatus, procedure and the way in which results are to be calculated.

### RINGELMANN CHART

No. 2742C. Price 3s. This new publication is the British Standard version of the Ringelmann chart, by means of which a visual assessment can be made of smoke emission from industrial chimneys. This method has been made the basis of assessing conformity with legislation under the Clean Air Act, which became fully effective on June 1. The chart will provide a standard yardstick for use in connection with the new legislation. The Act forbids pollution of the air by " dark smoke," the definition of which is smoke as dark as or darker than Shade 2 on the Ringelmann chart. The chart, printed on white board, consists of five 10cm squares ranging from No. 0, which is left white to indicate " no smoke," to No. 4, which is criss-crossed with thick, black lines to simulate black smoke. A black strip above the No. 4 square assists quality control during printing of the chart.

In practice the density of smoke emitted by a chimney is estimated by comparing the smoke with a Ringelmann chart held at such a distance from the observer that the black lines on the chart seem to merge into the white background producing, for each shade, an apparently uniform shade of grey. In producing the new chart a board has been chosen which will not be affected by water vapour in the atmosphere. Special care has been taken in the printing to achieve a high degree of accuracy.

Users will find the separate publication " Notes on the Use of the Ringelmann Chart " (B.S. 2742. Price 2s. 6d.) useful for reference.

### MACHINE SCREWS (UNIFIED THREADS) FOR AERONAUTICAL PURPOSES

No. A.204 to A.209 : 1957. Price 7s. 6d. This new British Standard specifies requirements for machine screws with Unified threads, for aeronautical purposes. It defines the dimensions, materials, finish and part numbers for 100 deg. countersunk head and pan head machine screws in steel, corrosion-resisting steel and aluminium alloy. Four sizes of screw are provided in each material, 4–40 UNC, 6–32 UNC, 8–32 UNC and 10–32 UNF, in lengths ranging from ¼in to 1½in.

## Launches and Trial Trips

NORTH COUNTESS, cargo ship ; built by the Blythswood Shipbuilding Company, Ltd., for Pan-conquista Compania Naviera S.A. ; length 485ft, breadth 67ft 6in, depth 41ft 10in, deadweight 15,200 tons on 31ft draught (closed shelter), trial speed 16 knots on 27ft 6in draught (open shelter), six holds, one 50-ton, one 25-ton and twelve 10-ton derricks, electric winches ; three 300kW diesel-driven generators ; Hawthorn-Doxford opposed piston, diaphragm oil engine 7200 b.h.p. Launch, April 16.

WIMBLEDON, closed shelter deck cargo liner ; built by Barclay, Curle and Co., Ltd., for the Britain Steamship Company, Ltd. ; length overall 487ft, breadth 63ft, depth to bridge deck 47ft, gross tonnage 9300 ; five main holds, derricks to lift 30 tons, 20 tons and 10 tons, electric deck machinery ; two 290kW diesel-driven generators, one 300kW Ruston Hornsby gas turbine generating set ; Barclay Curle-Doxford opposed piston diaphragm oil engine, six cylinders, 670mm diameter by 2320mm combined stroke. Trial, April 17.

DROXFORD, salvage ship ; built by John Lewis and Sons, Ltd., for Risdon Beazley, Ltd. ; length between perpendiculars 205ft, breadth moulded 37ft, depth moulded 18ft, gross tonnage 1302 ; single deck ; steam deck machinery ; triple expansion engine 1150 i.h.p. takes steam at 225 lb per square inch from a Scotch boiler. Trial, April 17.

EDENMORE, ore carrier ; built by the Blythswood Shipbuilding Company, Ltd., for Furness Withy and Co., Ltd. ; length 482ft, breadth 67ft, depth to upper deck 36ft 7in, three ore cargo holds with wing tanks, service speed 12 knots ; three 150kW diesel-driven generators ; Rowan-Doxford opposed piston, diaphragm oil engine, four cylinders 670mm diameter by 2320mm combined stroke, 4000 b.h.p. Trial, April 18.

TEMPLE MAIN, cargo liner ; built by the Caledon Shipbuilding and Engineering Company, Ltd., for the Temple Steamship Company, Ltd. ; length between perpendiculars 425ft, breadth moulded 58ft 6in, depth to shelter deck 37ft 9in, deadweight 10,400 tons on 26ft 11¼in draught, gross tonnage 8005 ; service speed 12 knots ; five cargo holds, bipod masts, one 50-ton, six 10-ton, six 5-ton ; electric deck machinery, three 200kW diesel-driven generators ; Vickers-Doxford oil engine 3300 b.h.p. at 108 r.p.m. Trial, April 19.

KATEA, cargo ship ; built by Alexander Stephen and Sons, Ltd., for the Union Steam Ship Company of New Zealand, Ltd. ; length 325ft, breadth 51ft, depth 26ft ; MacGregor hatch covers, twelve derricks, three hatches, electric winches ; Stephen-Sulzer single-acting diesel engine, six cylinders 600mm diameter by 1040mm stroke, 2410 b.h.p. at 128 r.p.m. Launch, April 22.

HUNTSFIELD, cargo ship ; built by the Burntisland Shipbuilding Company, Ltd., for the Power Steamship Company, Ltd. ; length between perpendiculars 450ft 3in, breadth moulded 63ft 11in, depth moulded to shelter deck 40ft 5in, deadweight 12,070 tons on 27ft 10½in draught ; four main cargo holds and deep tanks : four 210kW diesel-driven alternators ; Kincaird-B and W single-acting, diesel engine 6600 b.h.p. at 107 r.p.m. Trial, April.

ARALUEN, closed shelter deck cargo ship ; built by Smith's Dock Company, Ltd., for The Australind Steam Shipping Company, Ltd. ; length between perpendiculars 440ft, breadth moulded 60ft 3in, depth moulded to upper deck 38ft 9in, deadweight 11,050 tons on 28ft 6in draught, service speed 14¼ knots ; five cargo holds, one 70-ton, eight 10-ton and six 5-ton derricks, electric winches, three 200kW diesel-driven generators ; Hawthorn-Doxford opposed piston, two-stroke diaphragm engine, five cylinders 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 115 r.p.m. Trial, April.

BIRCHBANK, cargo ship ; built by William Doxford and Sons (Shipbuilders), Ltd., for the Bank Line, Ltd. ; length between perpendiculars 450ft, breadth moulded 62ft, depth moulded 38ft 6in, deadweight 12,120 tons on closed shelter deck draught ; one 25-ton, four 10-ton and ten 5-ton derricks, electric winches ; Doxford opposed piston oil engine, four cylinders 700mm diameter by 2320mm combined stroke, 4800 b.h.p. Trial, May 5.

AUCKLAND STAR, refrigerated cargo ship ; built by Cammell Laird and Co. (Shipbuilders and Engineers), Ltd., for the Salient Shipping Company (Bermuda), Ltd. ; length overall 570ft, breadth moulded to shelter deck 48ft 9in, draught moulded 31ft ; twelve passengers ; two continuous steel decks, seven holds, general cargo 320,000 cubic feet, insulated cargo 505,000 cubic feet, derricks to lift 5, 10 and 15 tons, electric winches ; four 330kW diesel-driven generators ; one set of double reduction geared turbines take steam at 500 lb per square inch and 800 deg. Fah. from two Babcock and Wilcox integral furnace watertube boilers. Launch, May 2.

DUKE OF SPARTA, cargo ship ; built by the Furness Shipbuilding Company, Ltd., for the Trent Maritime Company, Ltd. ; length between perpendiculars 480ft, breadth moulded 66ft, depth moulded to upper deck 42ft 6in, capacity 833,780 cubic feet, deadweight 15,750 tons on 31ft 2¾in summer draught ; five holds, fifteen derricks, electric winches ; three 200kW and one 50kW diesel-driven generators, Hawthorn-Doxford single-acting two-stroke opposed piston oil engine, five cylinders 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 115 r.p.m., arranged to burn heavy fuel. Launch, May 2.

## Catalogues and Brochures

WILLIAM JESSOP AND SONS, Ltd., Sheffield,—Information Sheet No. M783, dealing with the welding of titanium alloys.

ANGULA ENGINEERING COMPANY, Ltd., Glaskin Mews, Pembury Road, Clapton, London, E.5.—Illustrated leaflet describing a parallel motion drafting machine.

TURNERS ASBESTOS CEMENT COMPANY, Ltd., Trafford Park, Manchester, 17.—Data and information booklet describing " Everite " standard lightweight asbestos cement corrugated sheets.

THE MORGAN CRUCIBLE COMPANY, Ltd., Battersea Church Road, London, S.W.11.—Illustrated leaflet describing the history and development of the company. A complete list of products and subsidiary and associated companies is included.

THE CONSOLIDATED PNEUMATIC TOOL COMPANY, Ltd., 232, Dawes Road, London, S.W.6.—Illustrated brochure giving details of pendant hoists, horizontal bench and wall rams, vertical inverted and table top rams, the new cushioned ram, the pendant hoist with sensitive control valve, and rams equipped with movable trunnions. The brochure contains general summaries with capacities and types.

THE ENGLISH ELECTRIC COMPANY, Ltd., Stafford.—Publications entitled " Open-Type Substation Fusegear," " Red Spot Heavy Duty Fuseboards," " British Standard Dimensioned Ventilated Motors, 'C' Range," " ½ H.P. 'Magamp' Motor Control Unit," " 3 H.P. Motor Controller," " Nuclear Reactor Simulator," " E.H.V. Air-Blast Circuit Breakers, 220–345kV Frame 'm,' " " Rectifier Equipments for Industrial D.C. Supplies—up to 210A—up to 600V," " Germanium Rectifiers," " 66/69kV Outdoor Oil Circuit Breaker Type OKM6," " Metal-Clad Switchgear for 33kV Service," and " Control Switch—Type ODC."

## Forthcoming Engagements

*Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the* TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

### PHYSICAL SOCIETY

*To-day and Sat., July 4 and 5.*—OPTICAL GROUP : Department of Glass Technology, Sheffield University, " Elmfield," Northumberland Road, Sheffield, 10, Summer Provincial Meeting.

### ROYAL INSTITUTION OF CHARTERED SURVEYORS

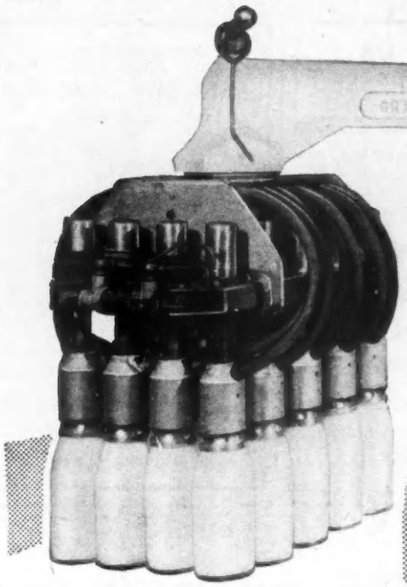
*To-day and Sat., July 4 and 5.*—The University, Exeter, Annual Conference, " The Development of Land as an Investment for the Future."

## Advanced Engineering Courses

**Applications of Computers.** THE UNIVERSITY OF NOTTINGHAM, DEPARTMENT OF MECHANICAL ENGINEERING, University Park, Nottingham. One week's residential course, Monday to Friday, September 15 to 19. Course, including notes, ten guineas. Accommodation, eight guineas.

**Graduate Course in Engineering Production.** DEPARTMENT OF ENGINEERING PRODUCTION, The University, Edgbaston, Birmingham, 15. Post-graduate course of studies leading to the degree of Master of Science and to the Diploma for Graduate Studies in the Principles of Engineering Production and Management. Application for admission to the course, which lasts one year, should be submitted to the Registrar by July 30. Fee £95.

**Graduate Course in Operational Research.** DEPARTMENT OF ENGINEERING PRODUCTION, The University, Edgbaston, Birmingham, 15. Post-graduate course of studies leading to the degree of Master of Science in Operational Research. Application for admission to the course, which lasts one year, should be submitted to the Registrar by July 30. Fee £95.



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Water vapour is always present in compressed air, building up unseen corrosion, blockages and, finally, expensive maintenance problems.

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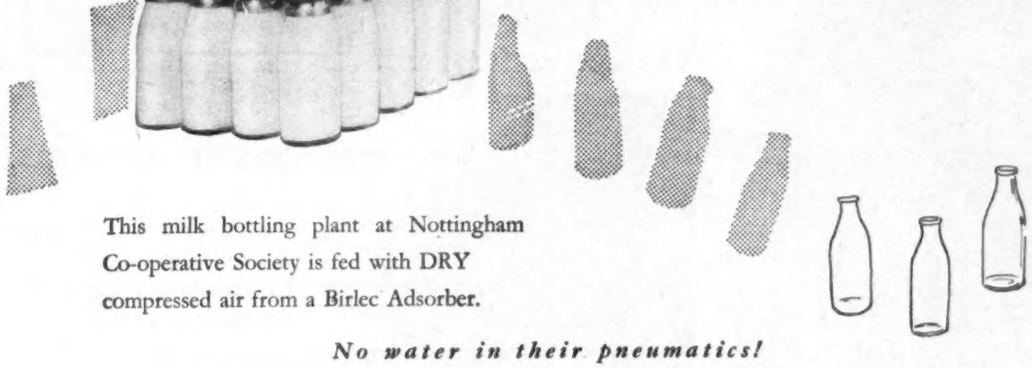

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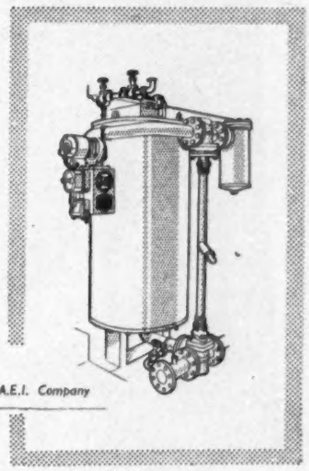

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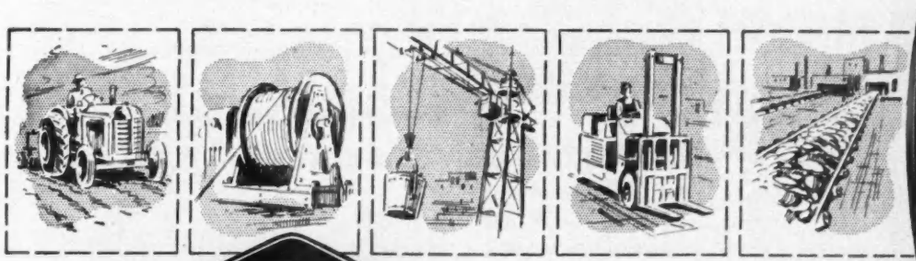

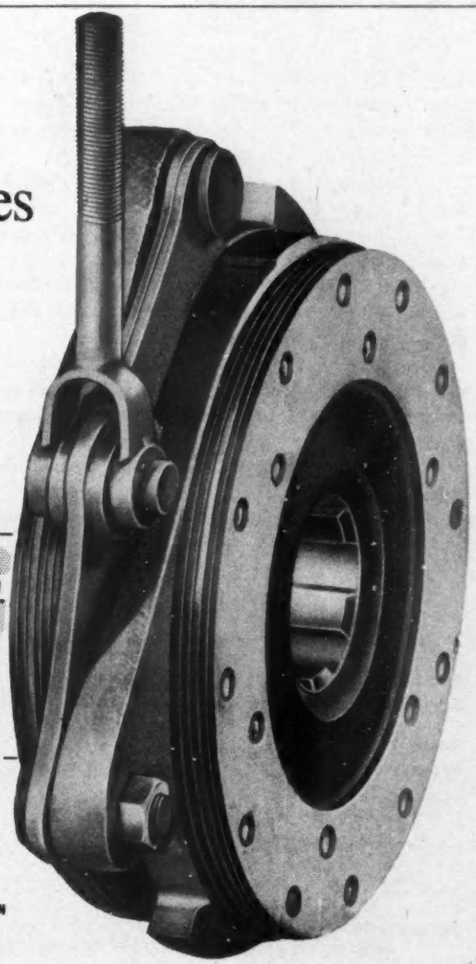

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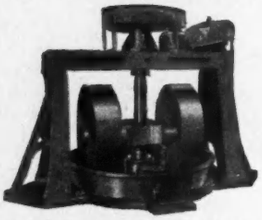

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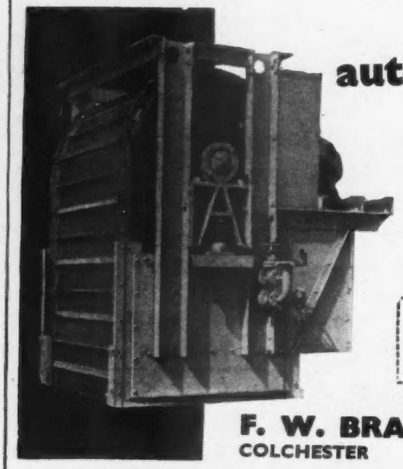

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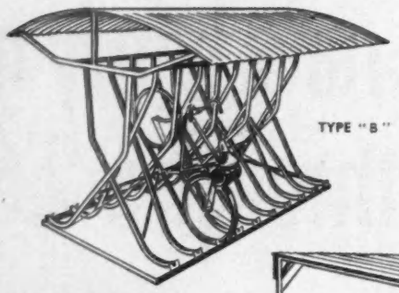

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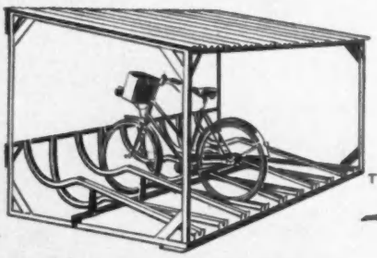

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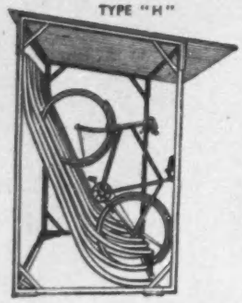

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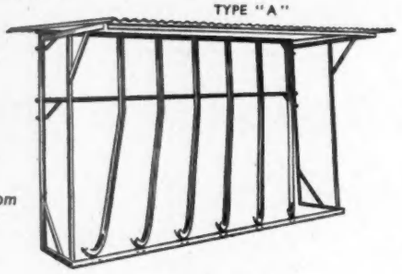

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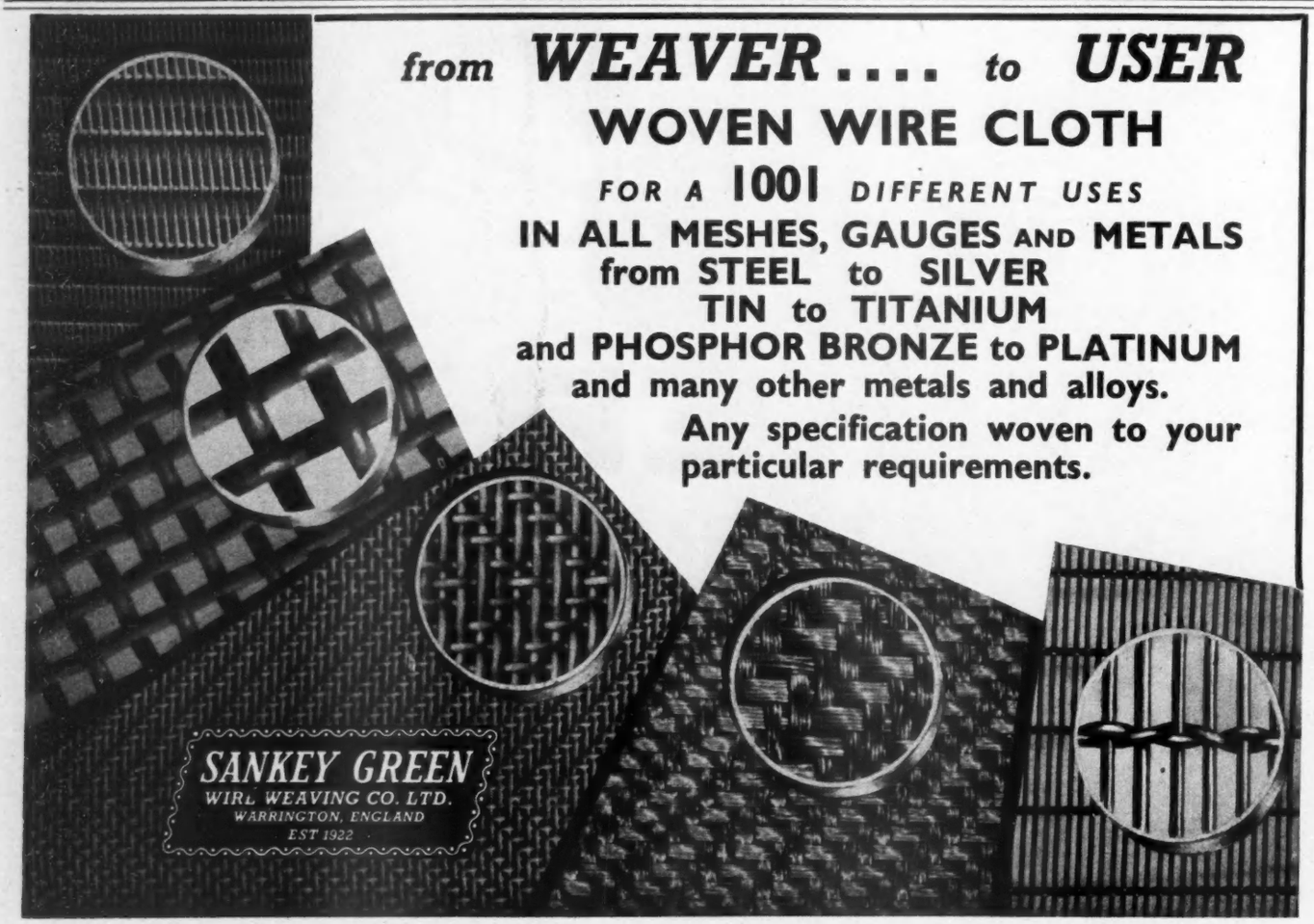

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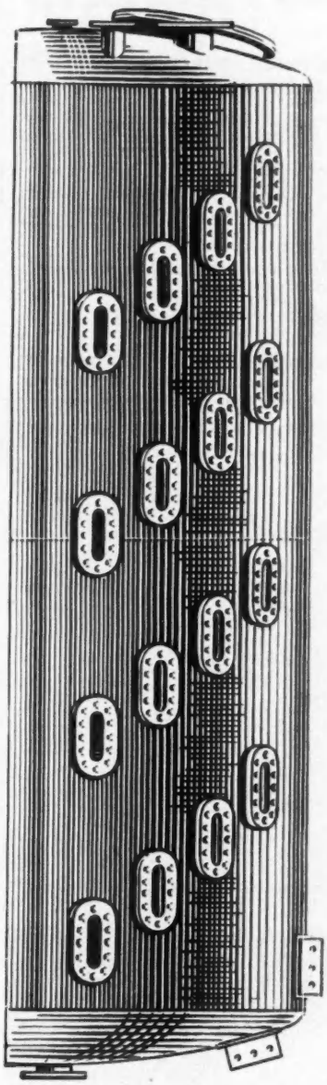

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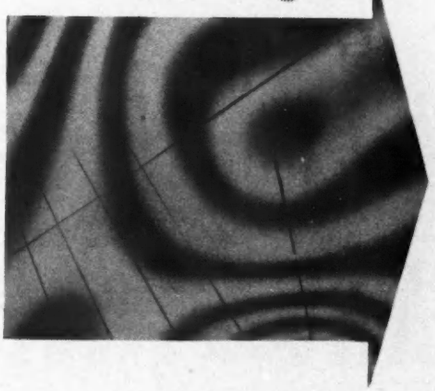

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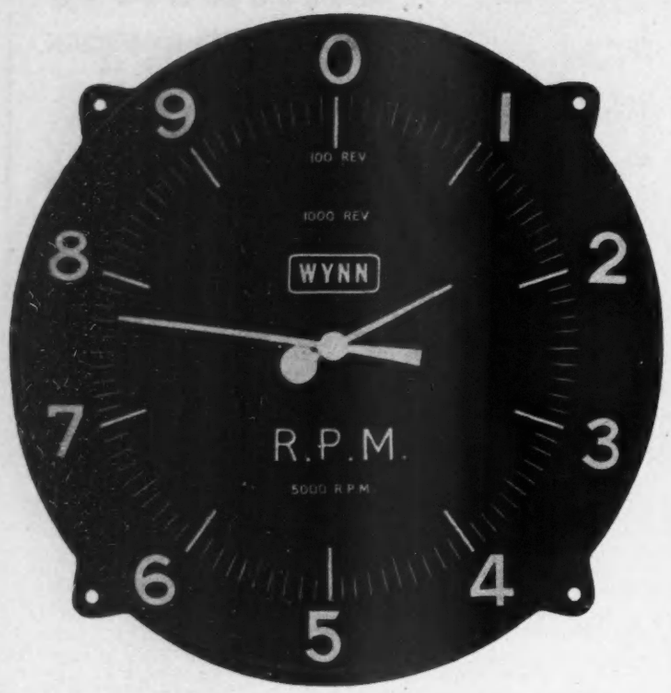


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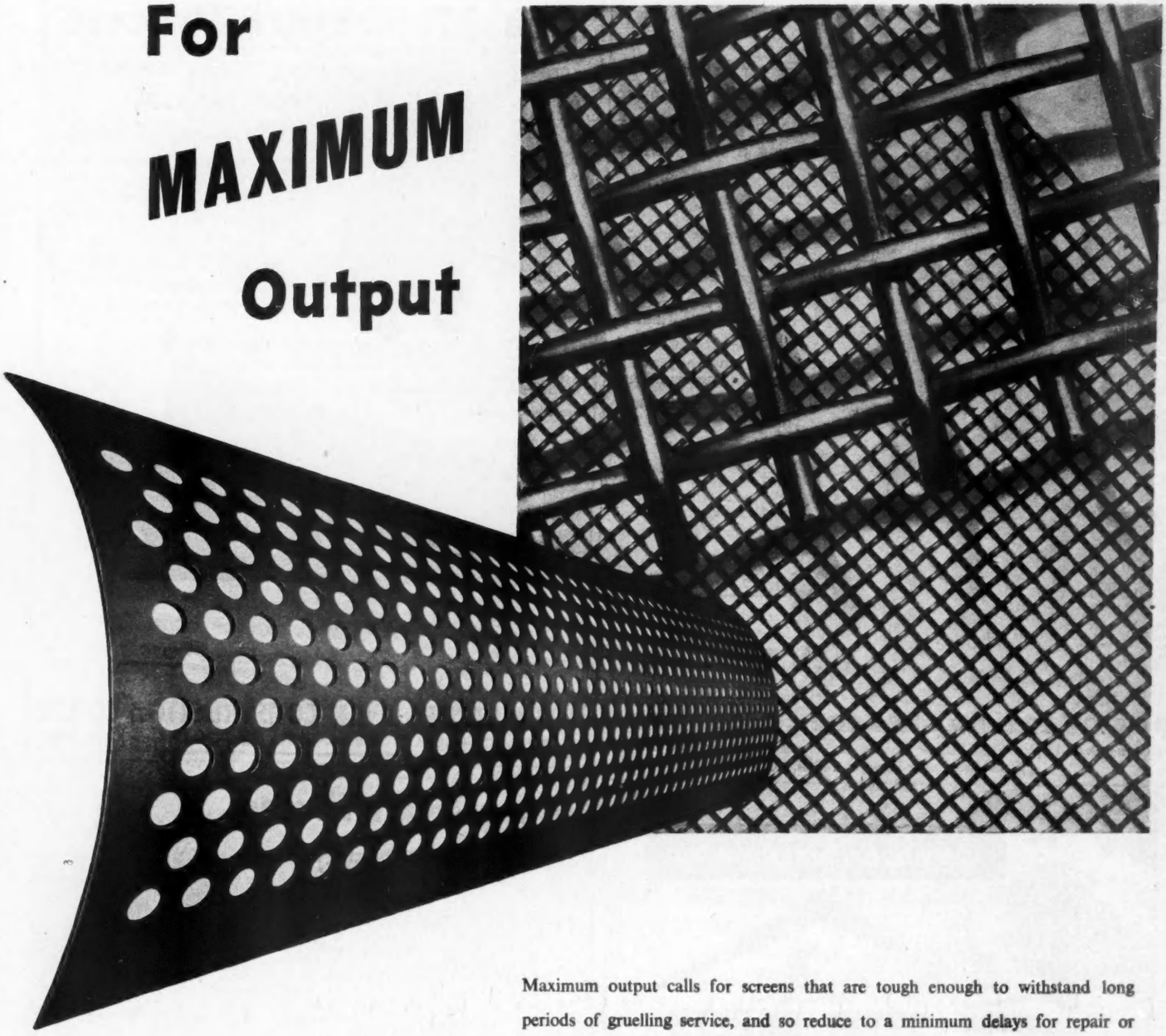

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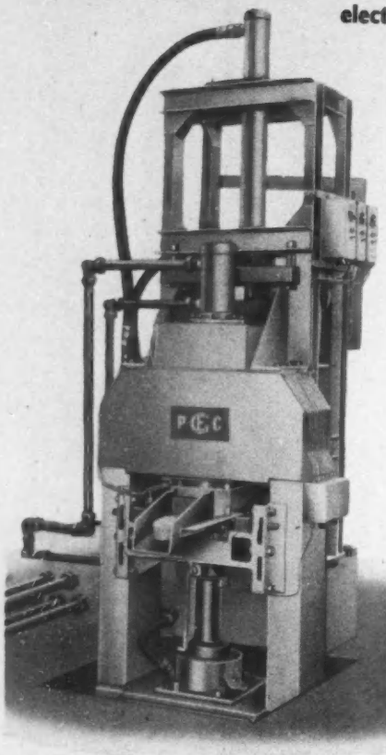

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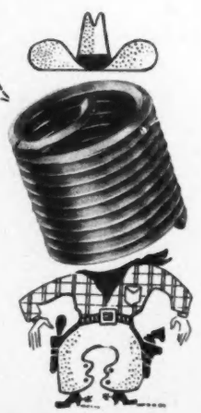

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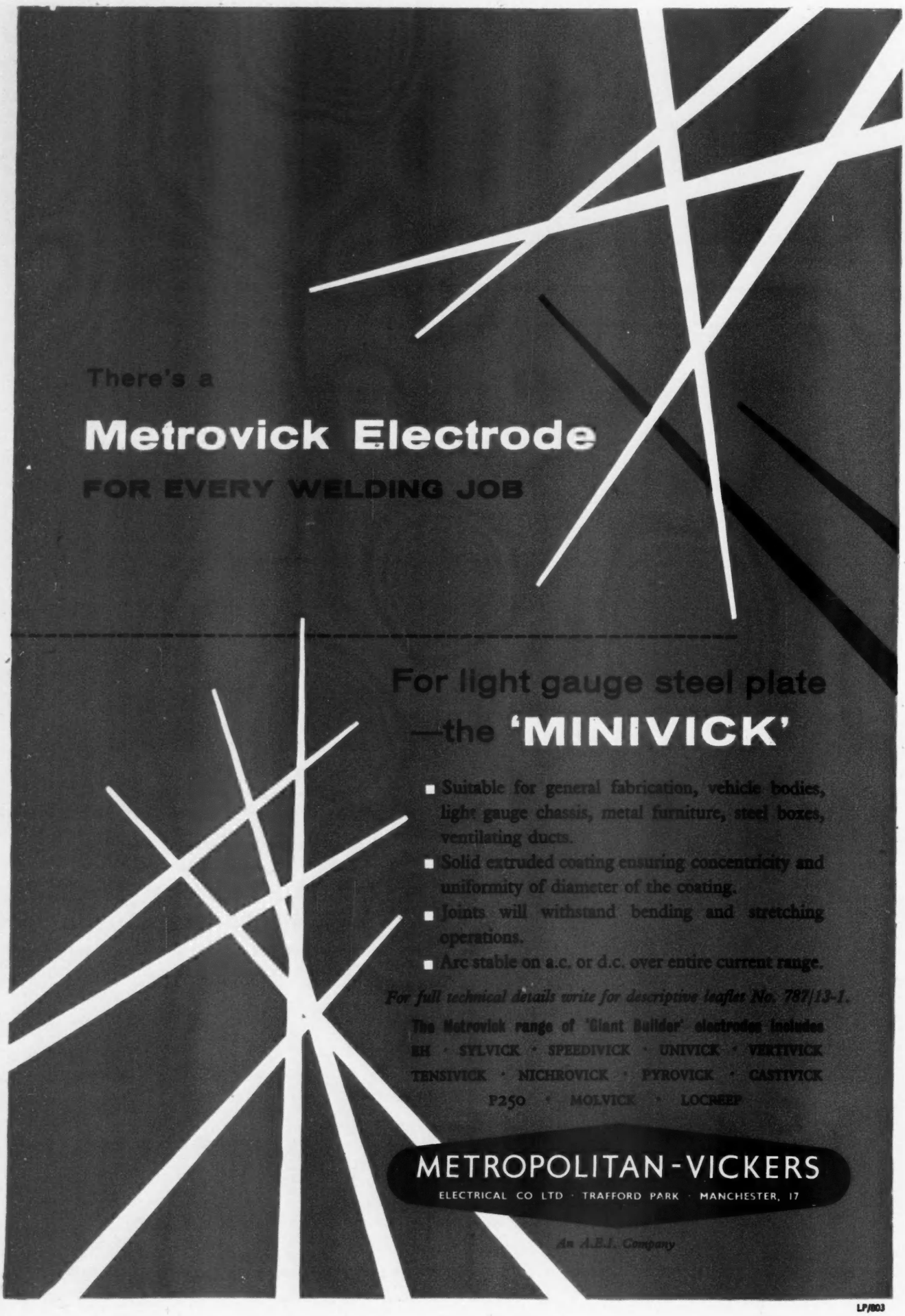
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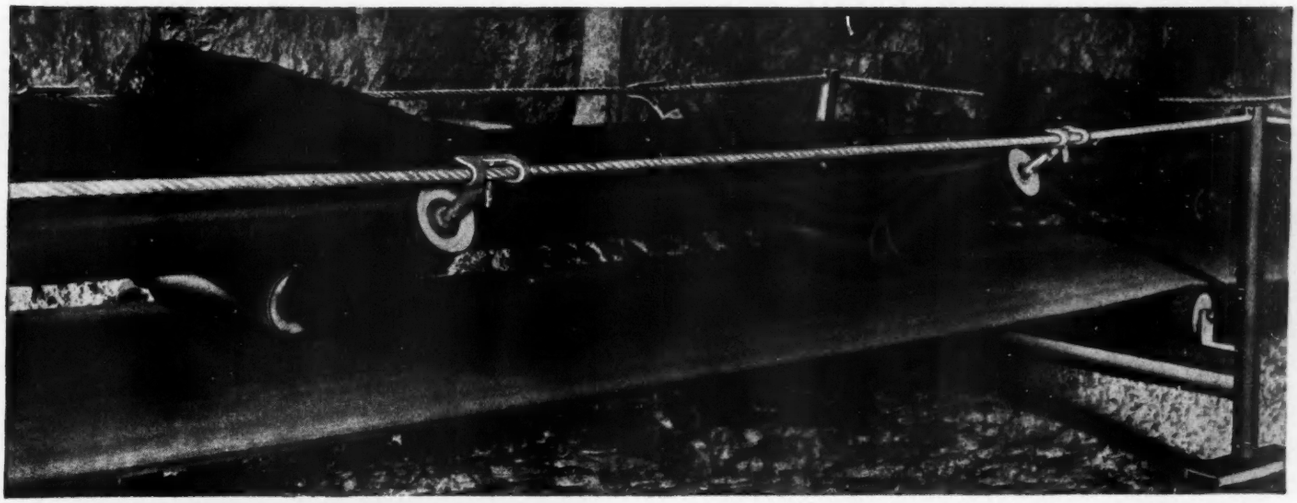

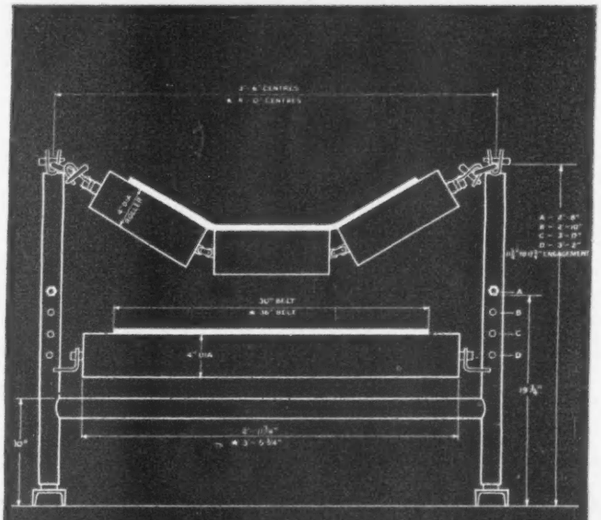

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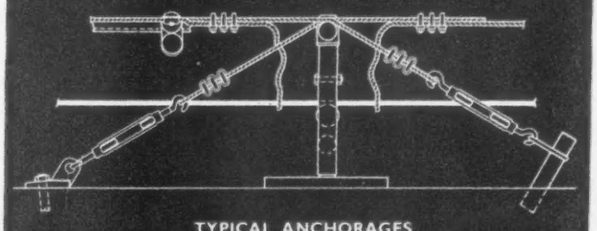

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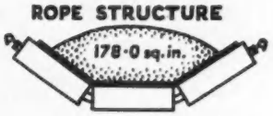


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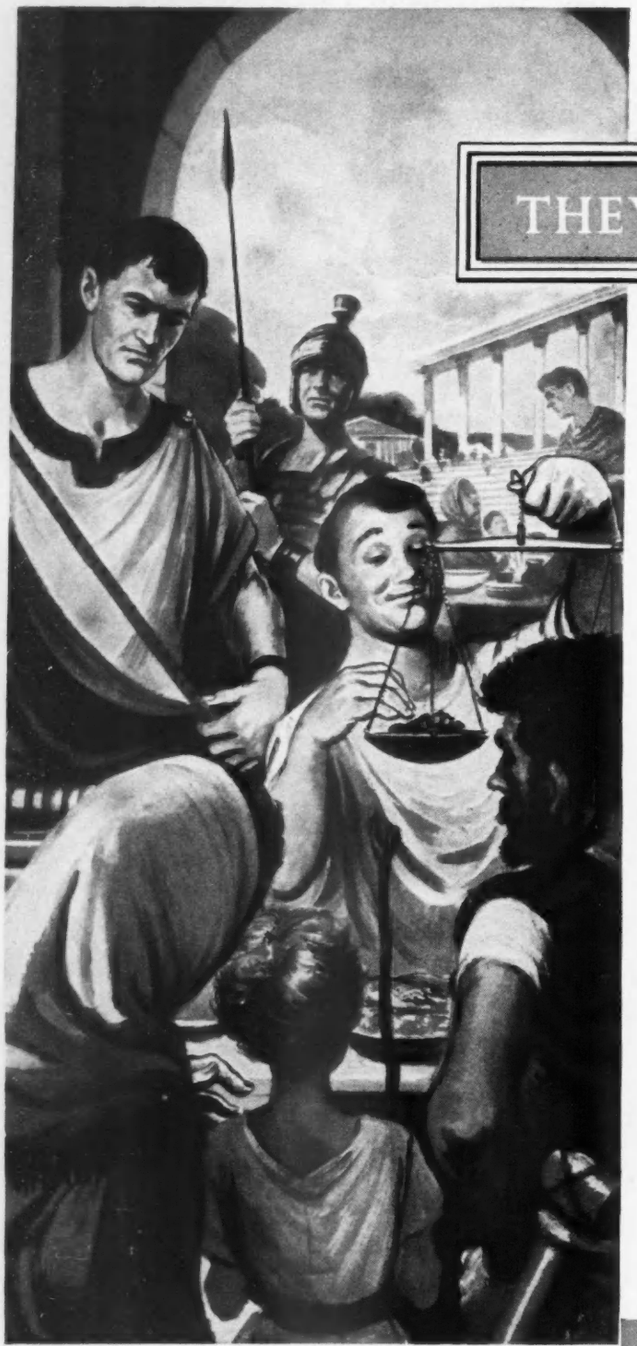

*The market-place of a Roman town A.D.350.*

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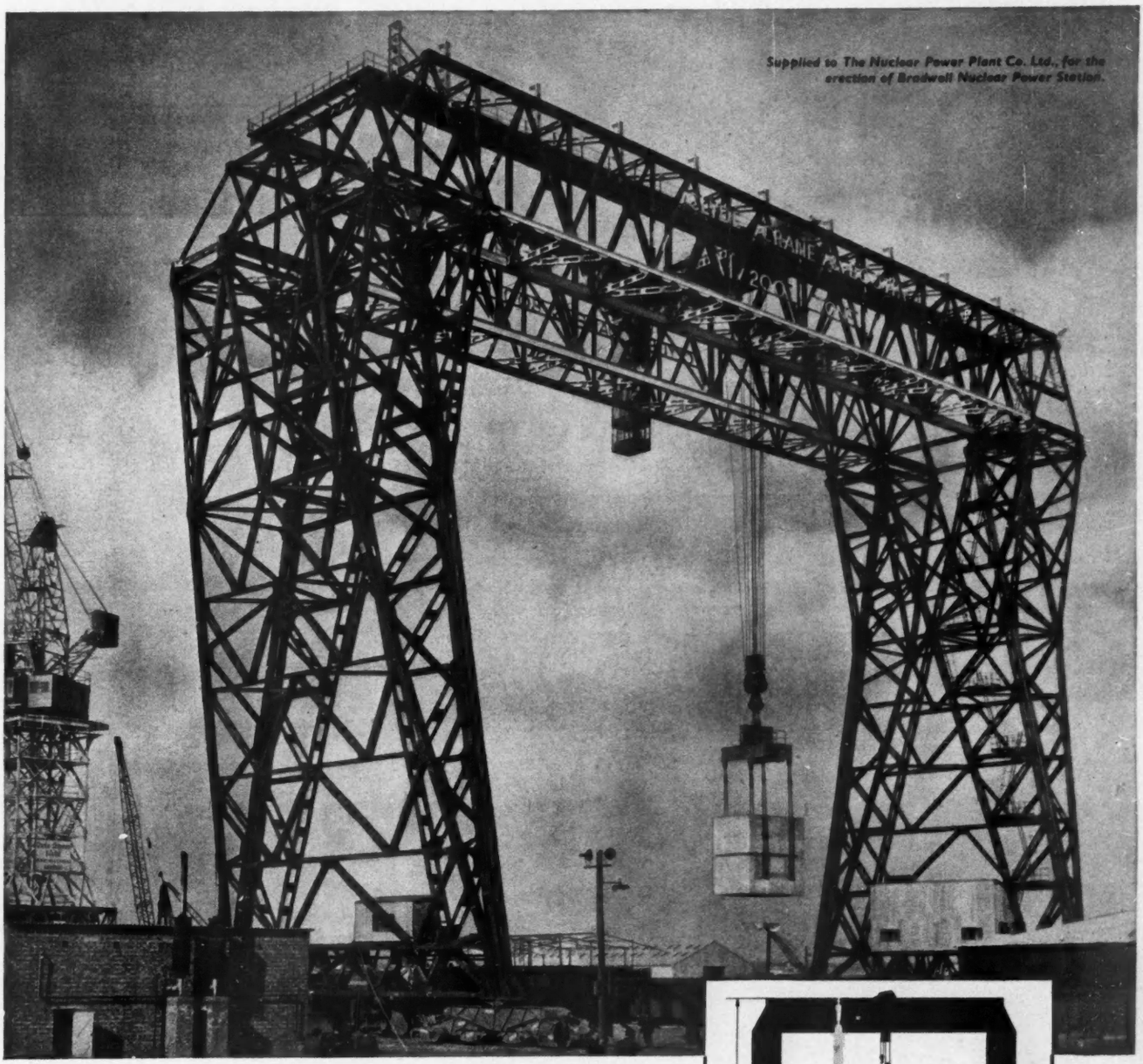


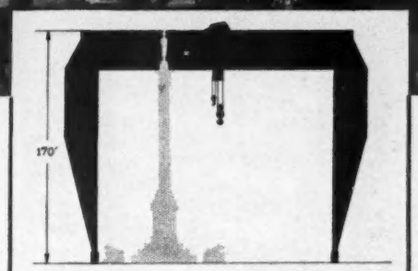


*The Booth Goliath showing Nelsons Column on the same scale. Clearance from rail level to underside of bridge is 140'. Distance between rail centres 178'.*

**Shown lifting concrete test blocks representing the maximum working load of 200 tons, this Goliath was built by Clyde Crane & Booth Ltd., for the erection of Bradwell Nuclear Power Station. Taking into account the lifting capacity and overall dimensions, it is believed to be the largest of its type in operation in this country and probably the world.**

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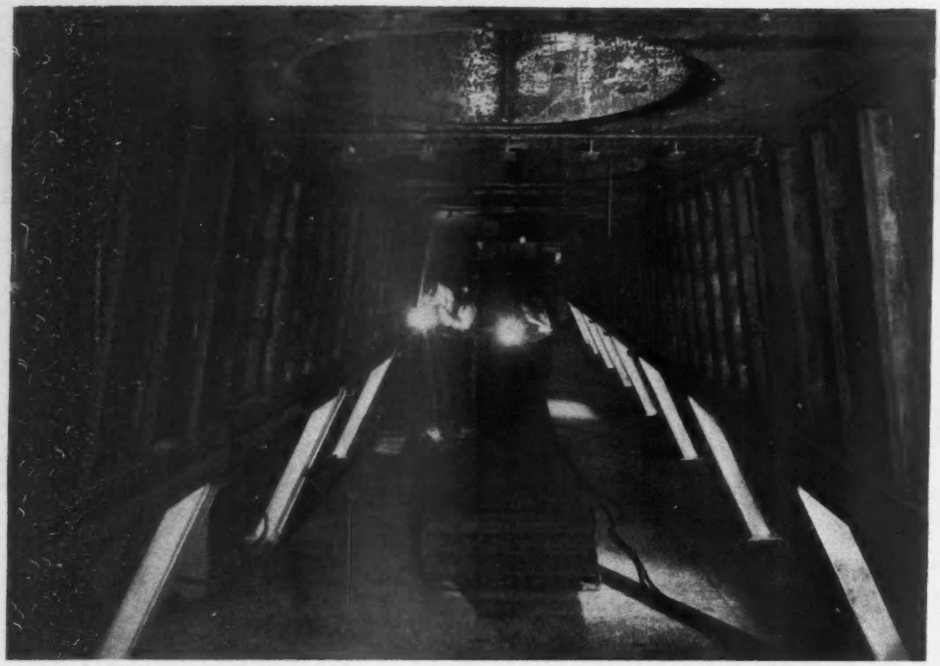

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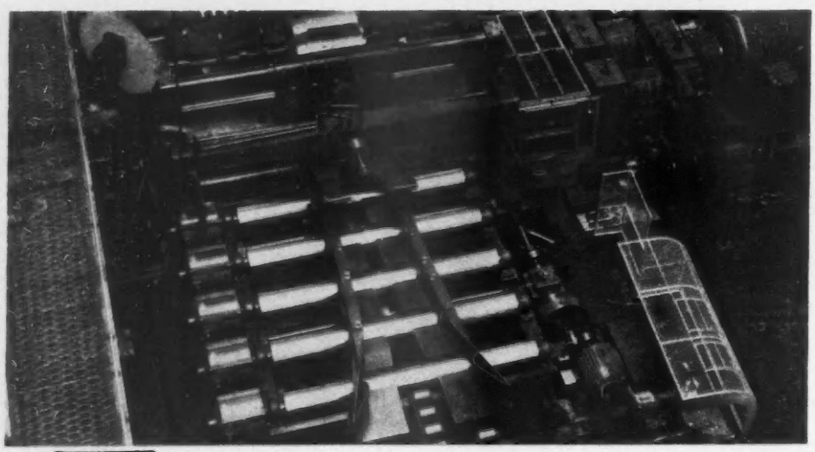

*Armourchromed Rolls, over 11ft long, in use at Banbury.*
*Photograph by courtesy of The Northern Aluminium Co. Ltd.*

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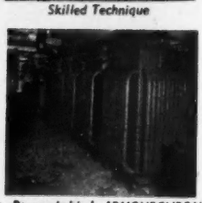

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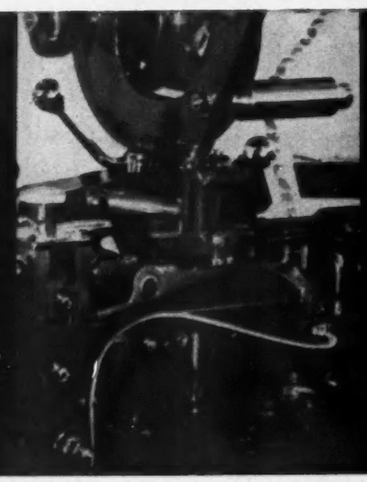

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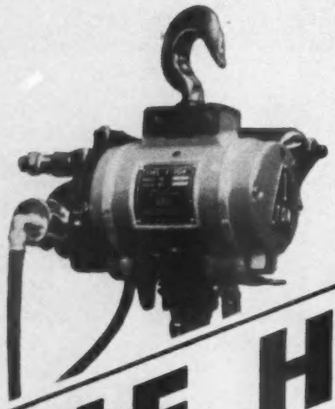

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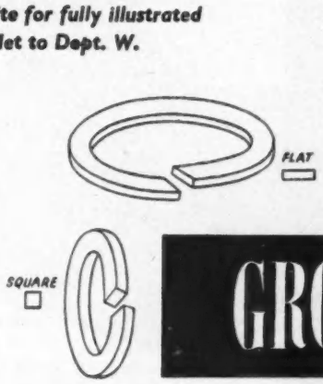


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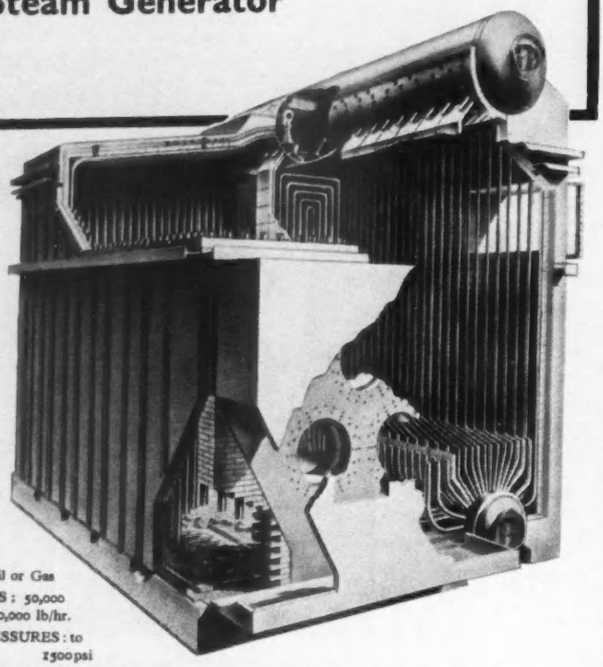
## Series "SC" STANDARD
### Steam Generator



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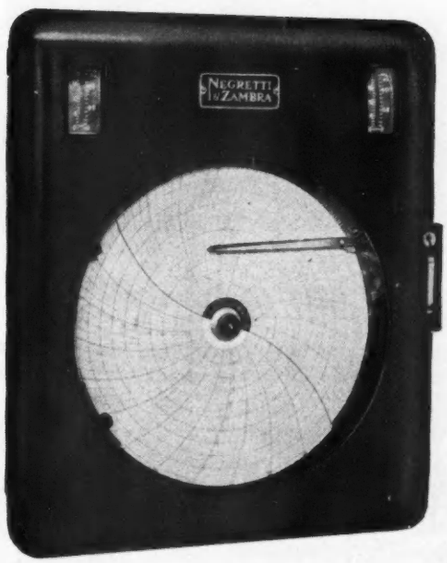
1 **BASIC CONTROLLER :** ***for use when manual control is not required.***

2 **CONTROLLER :** ***incorporating facilities for manual control internally.***

3 **CONTROLLER :** ***with auto/manual test facilities mounted externally on a sub-panel.***

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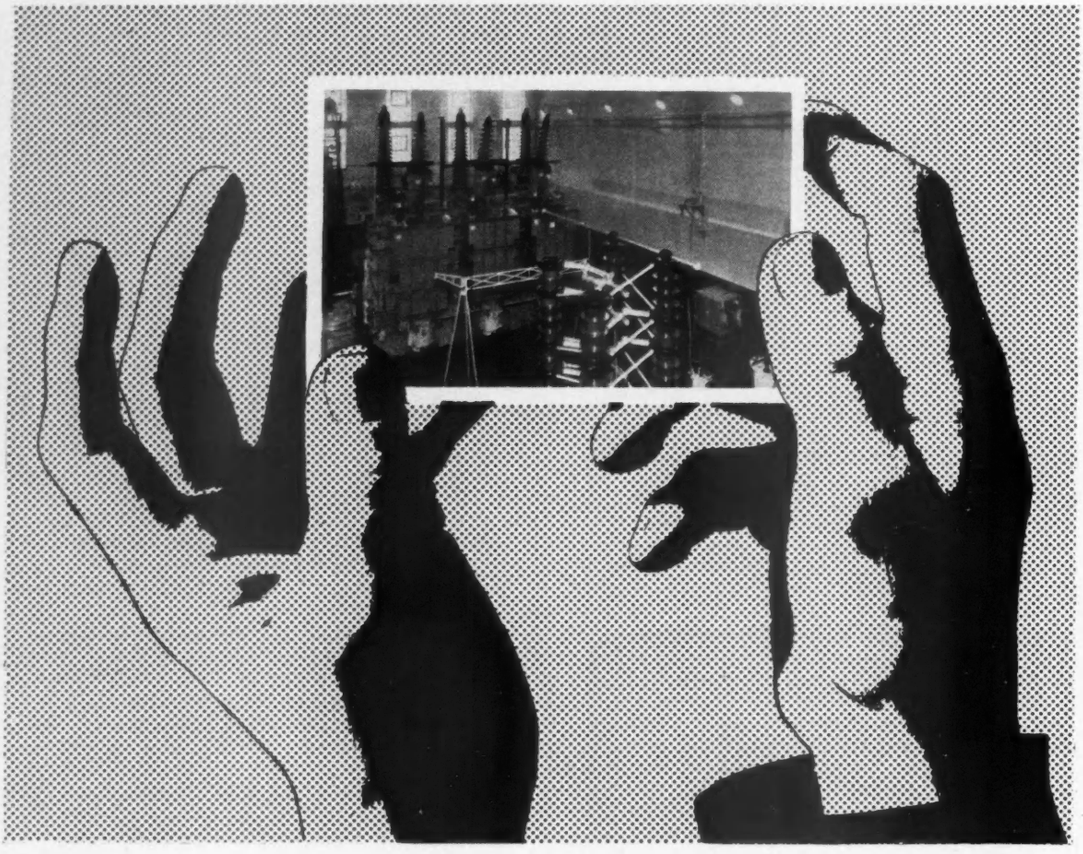

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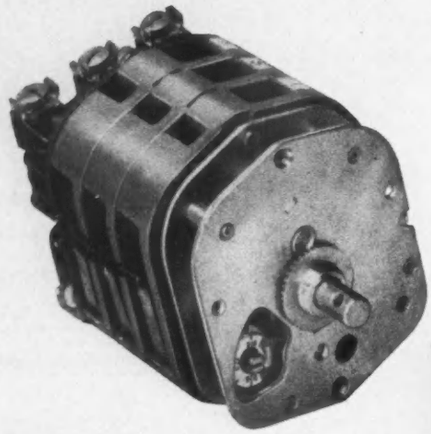

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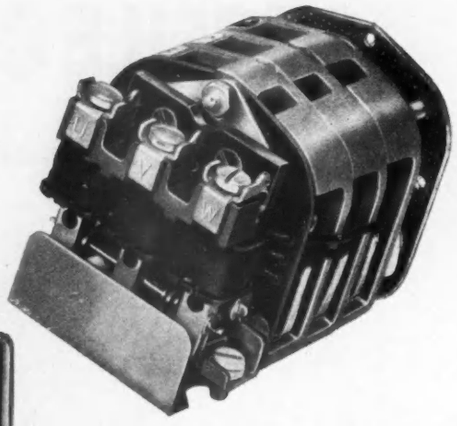


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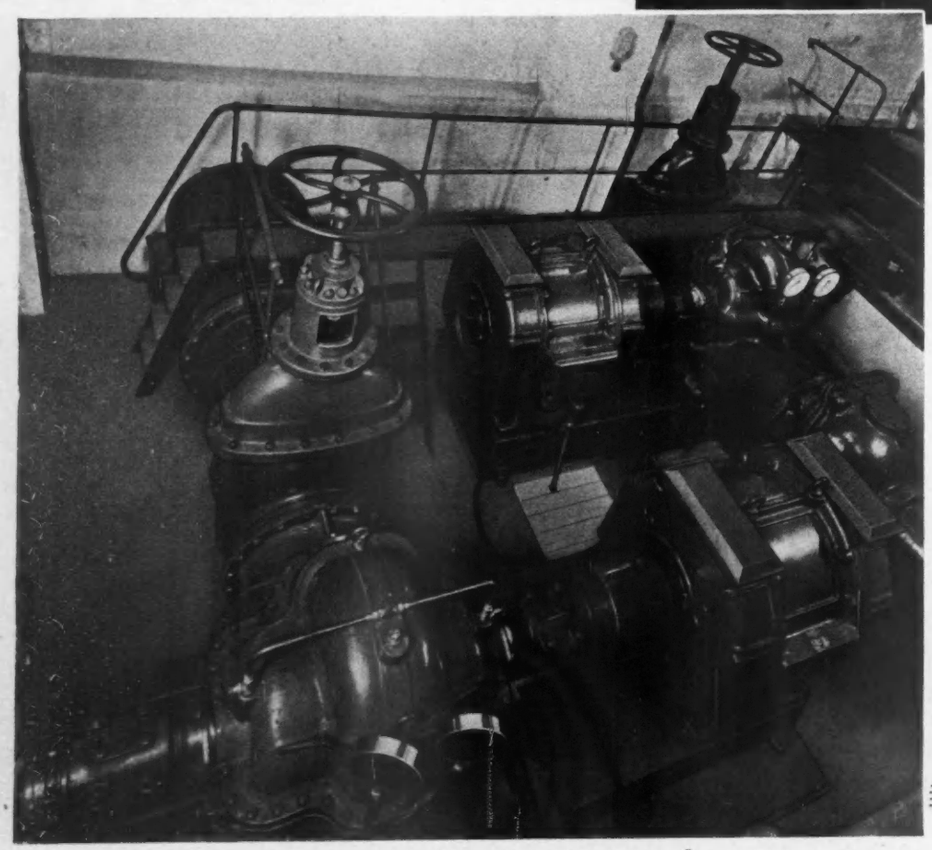

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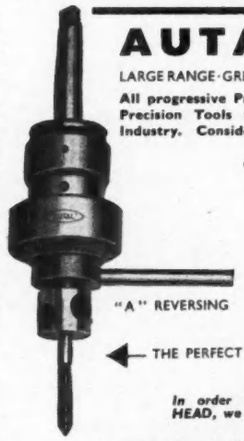

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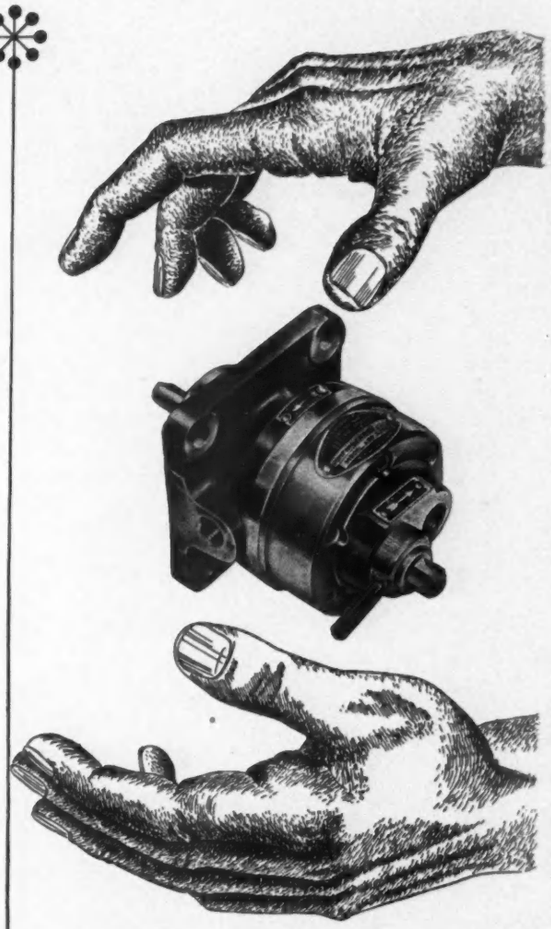

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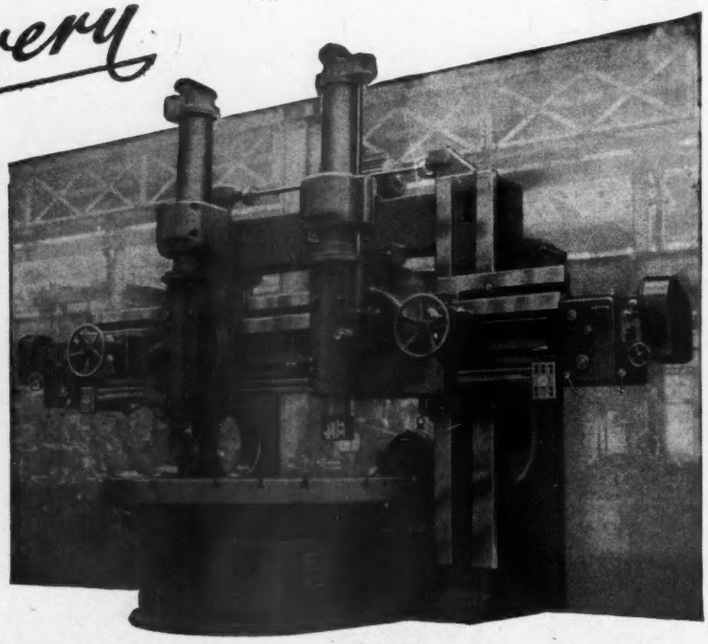

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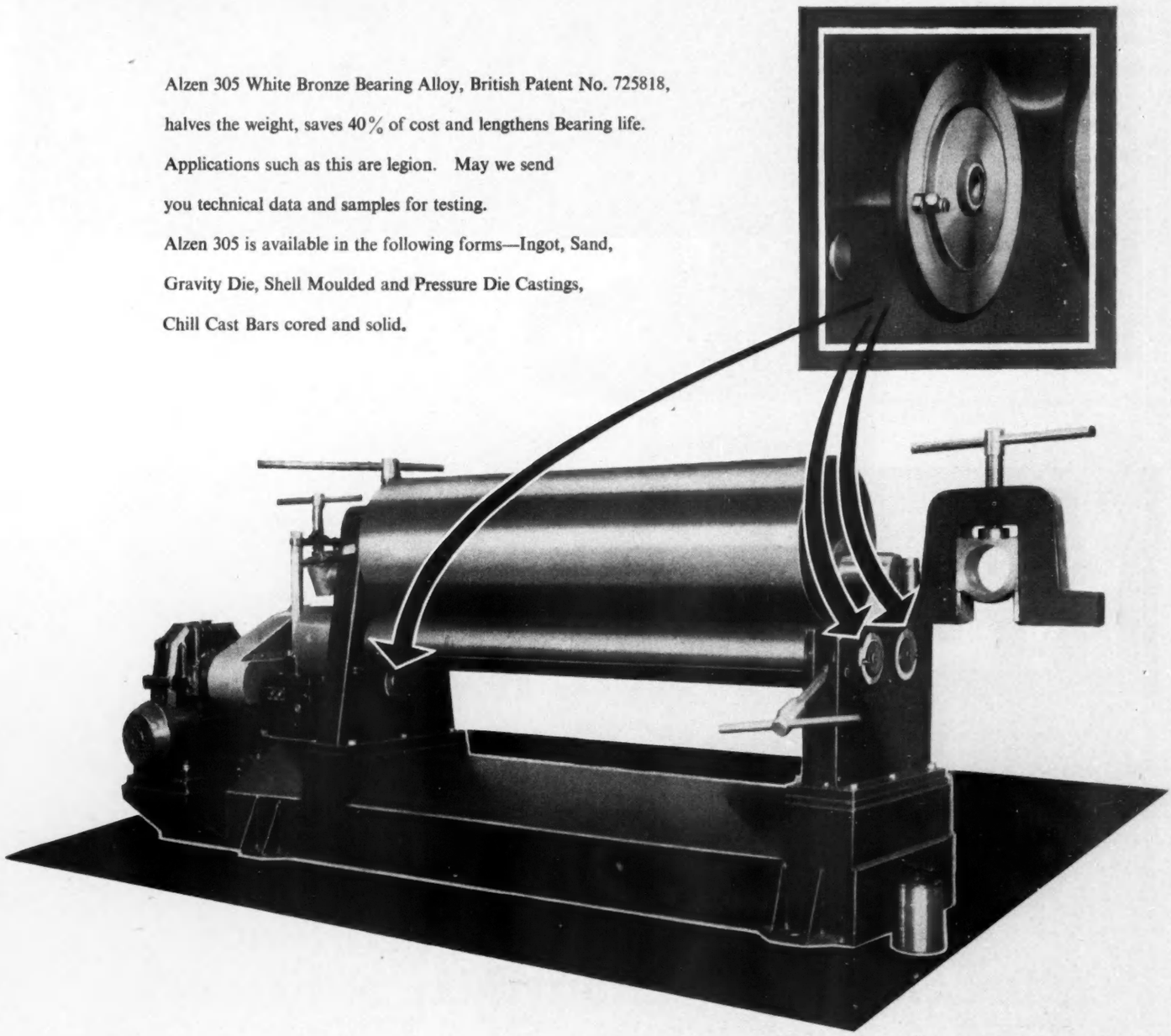

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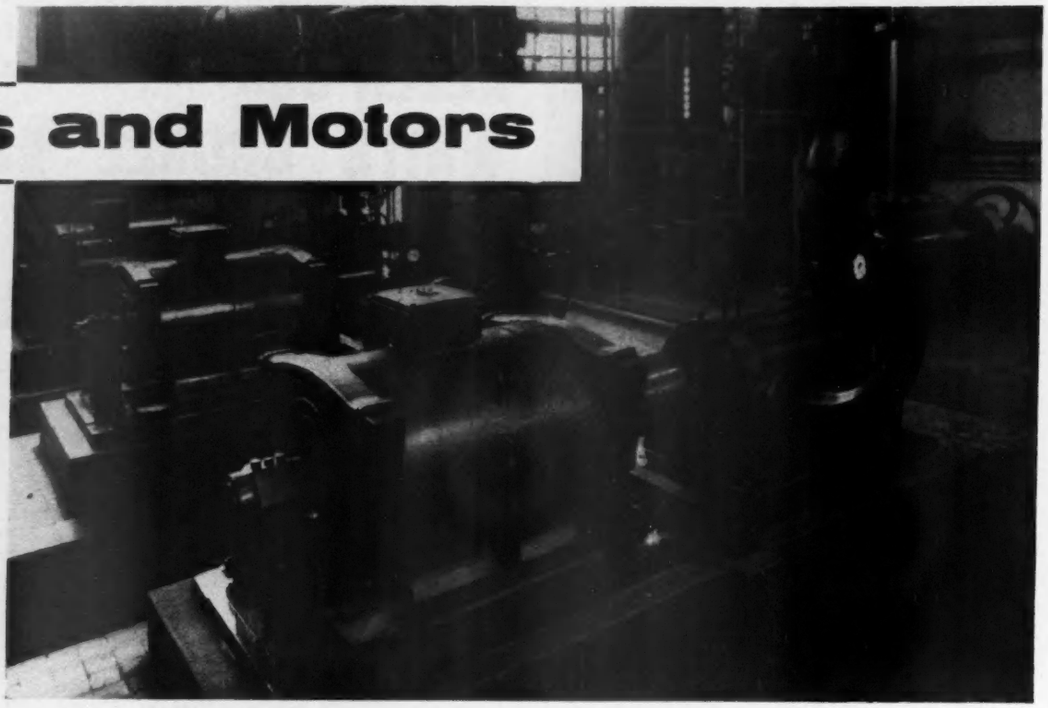

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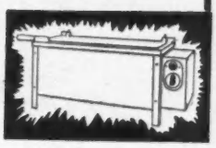

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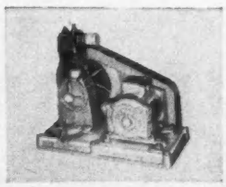

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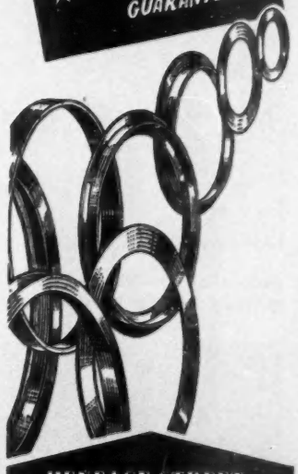

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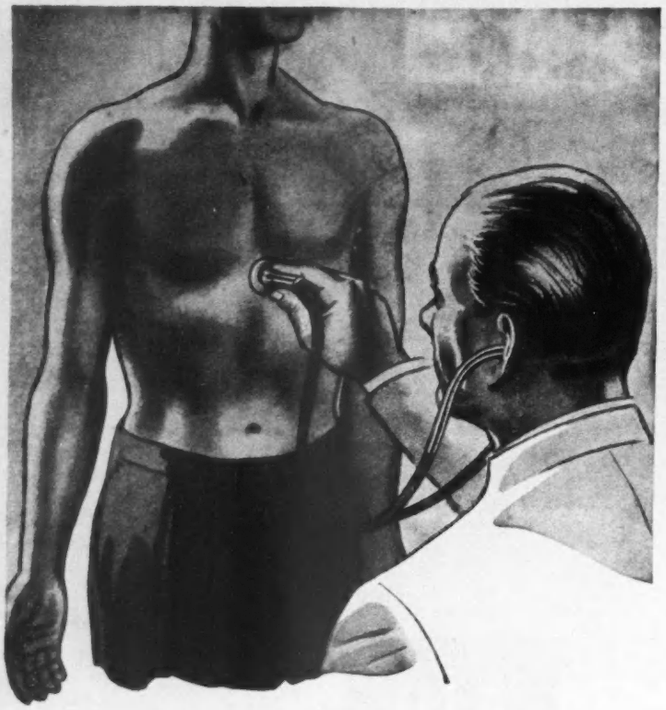

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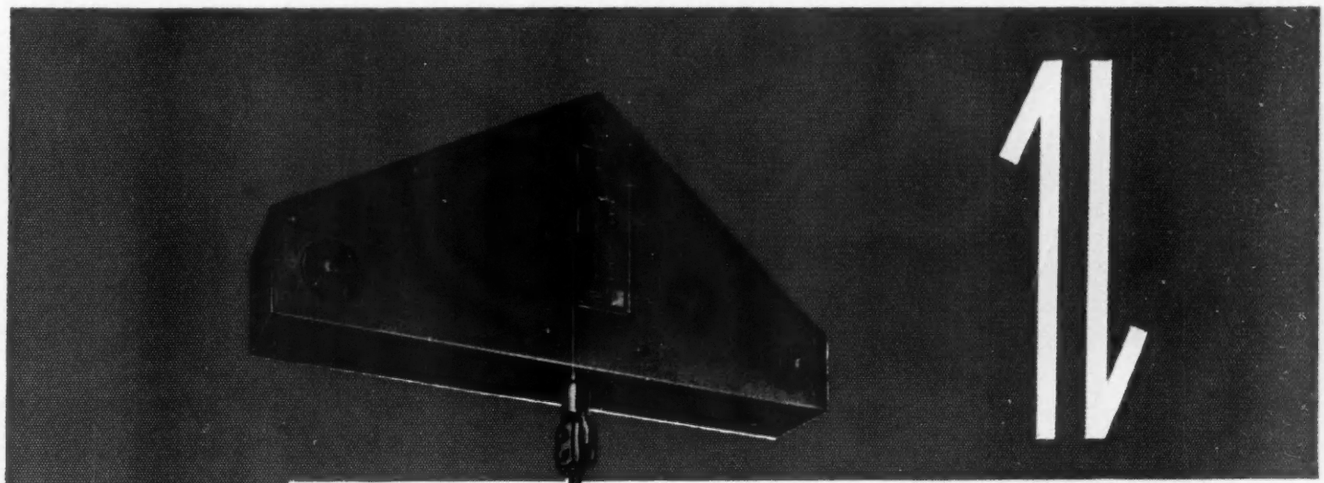

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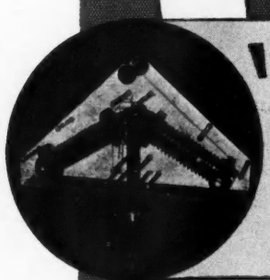

# 'UNILOAD' CONSTANT LOAD PIPE SUPPORTS

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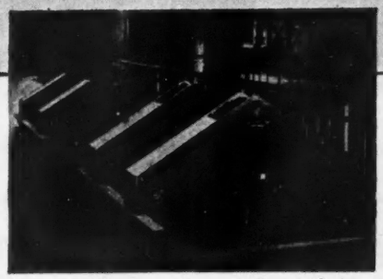

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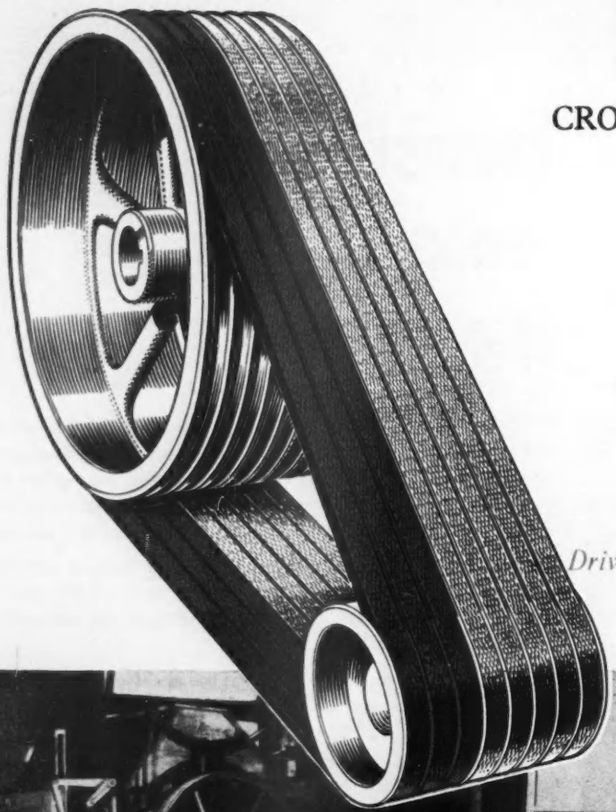

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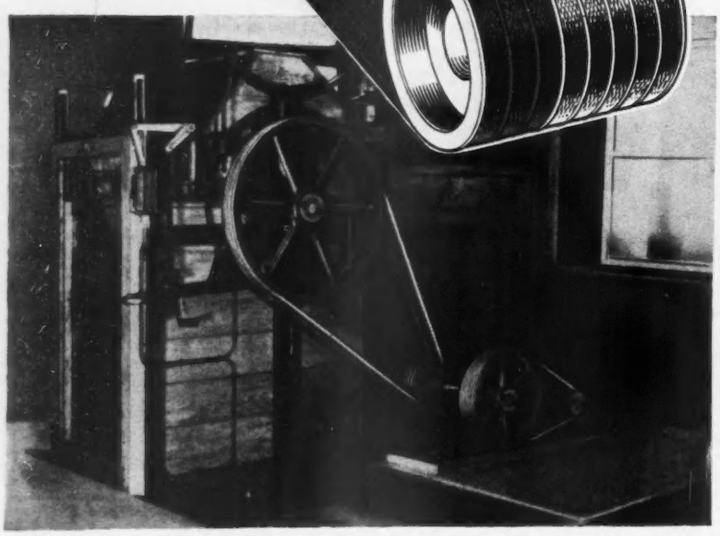

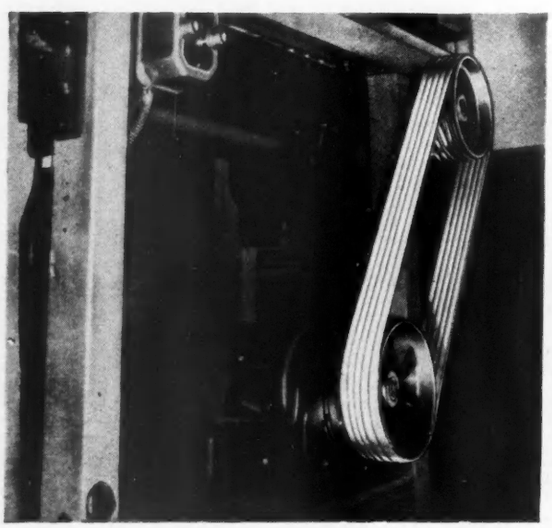

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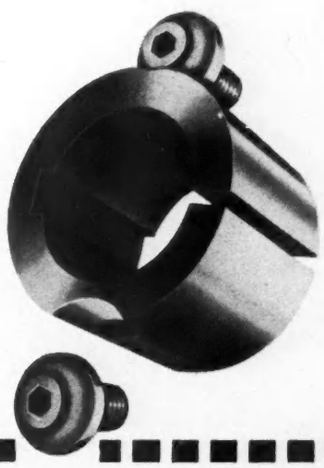

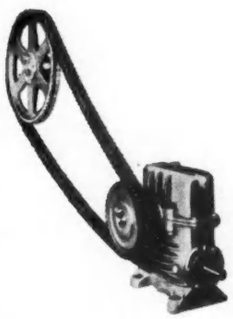

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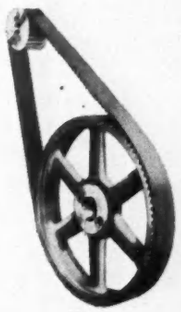

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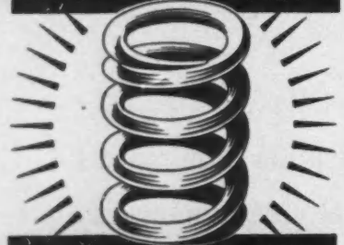

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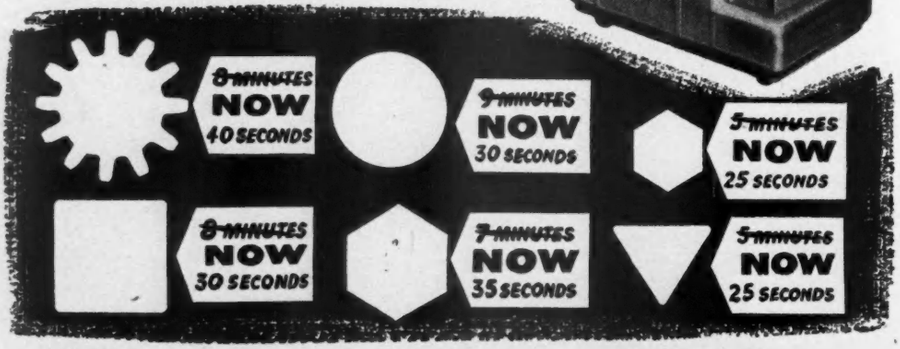
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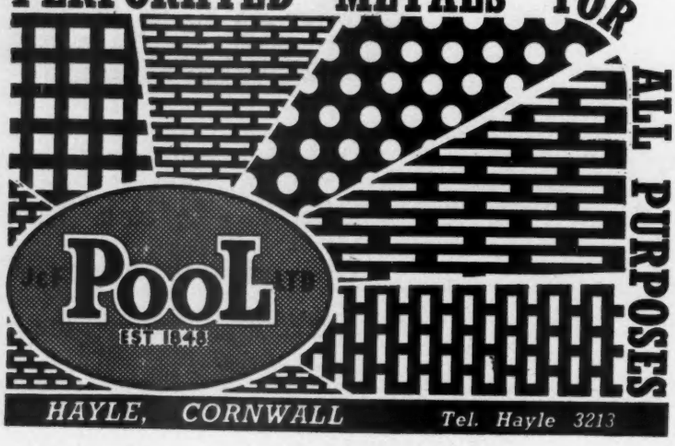


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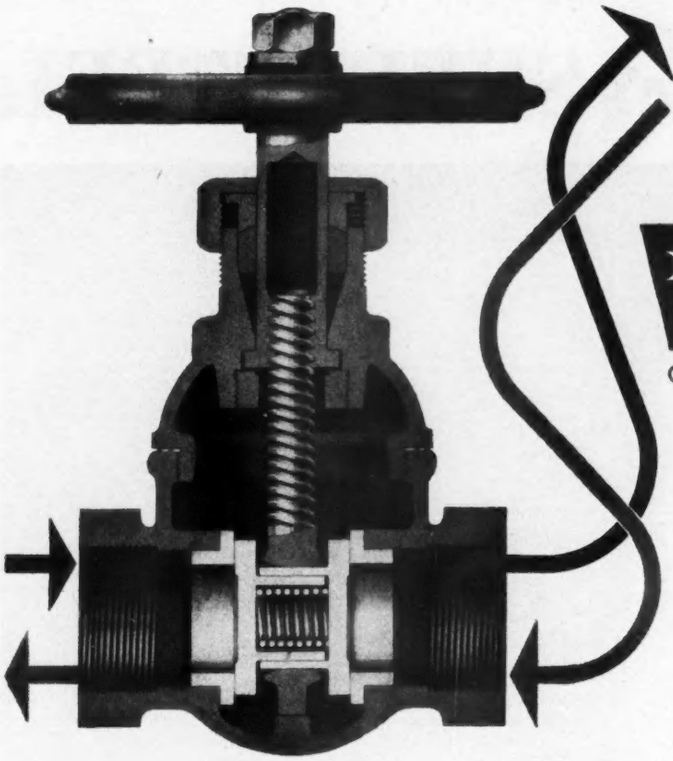

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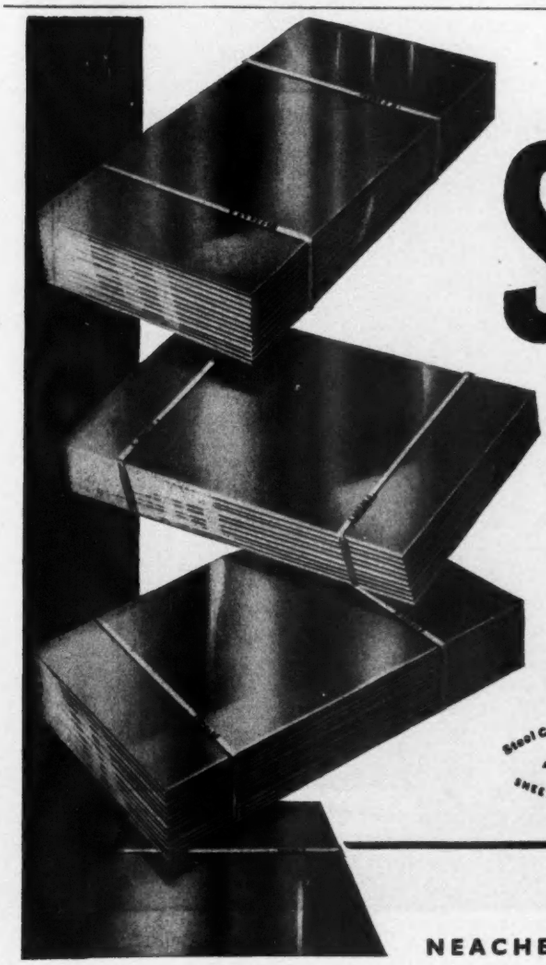

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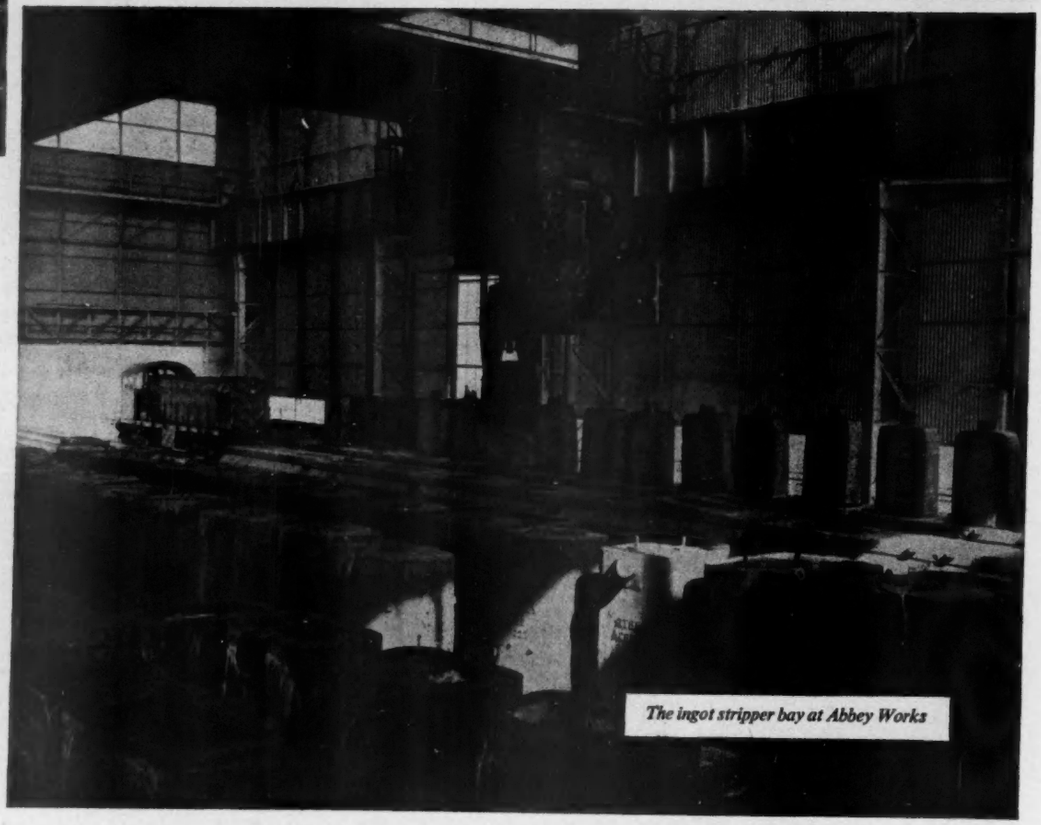

*The ingot stripper bay at Abbey Works*

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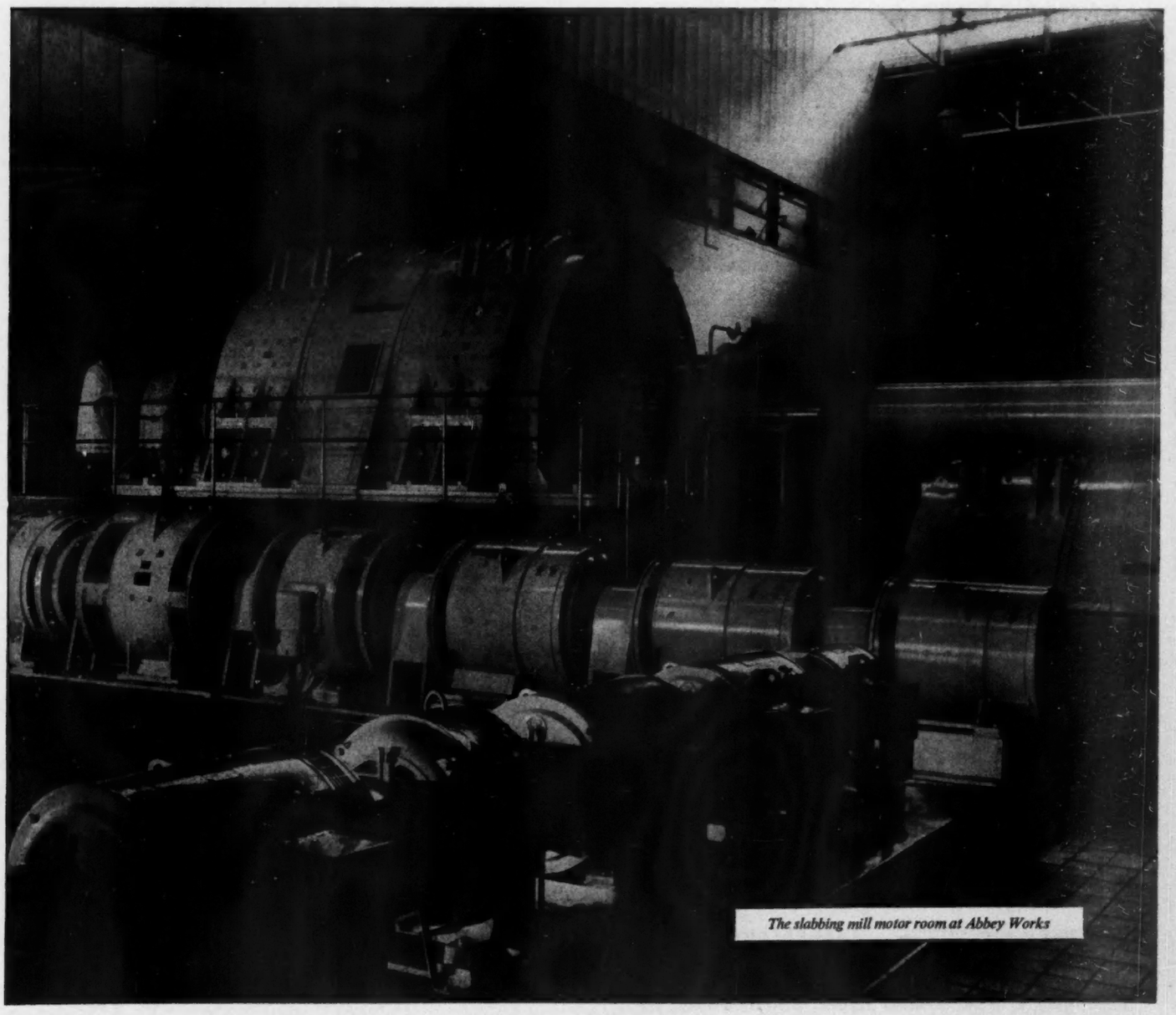

*The slabbing mill motor room at Abbey Works*

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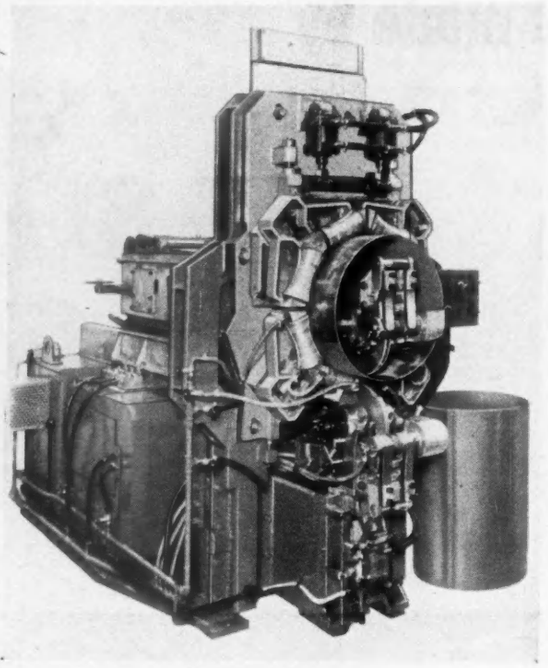

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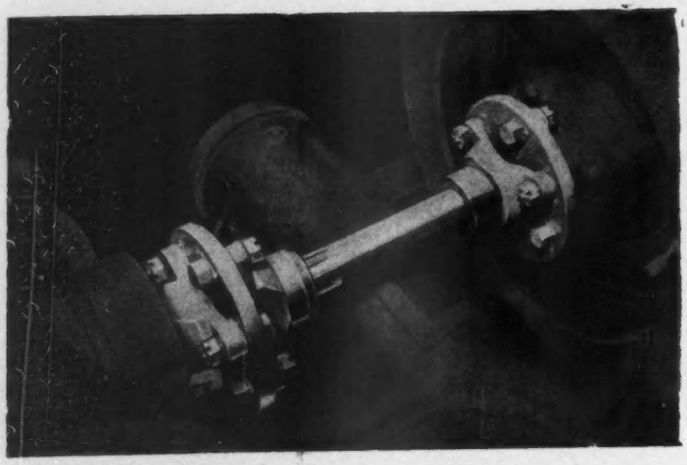

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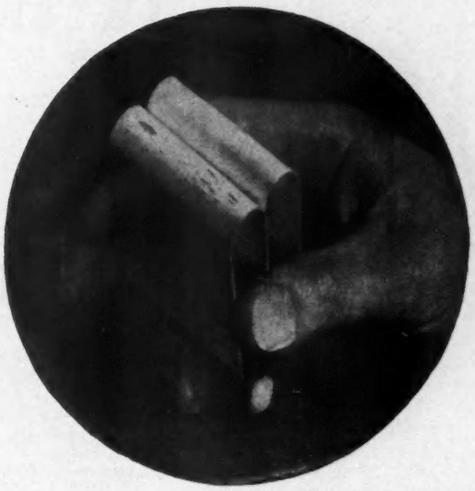

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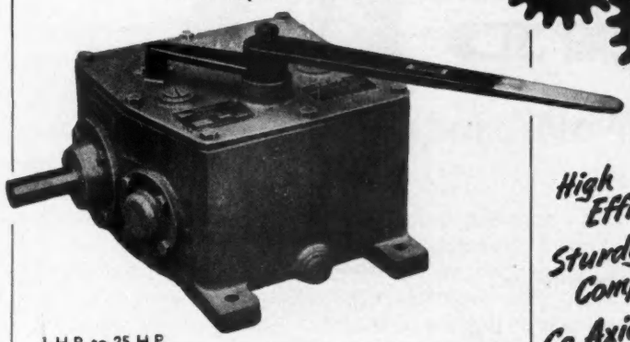

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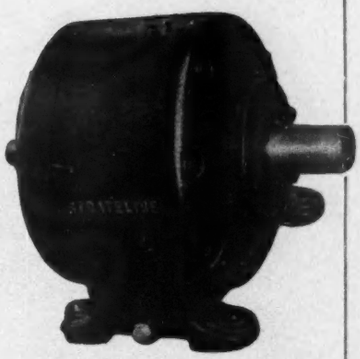

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No. 29

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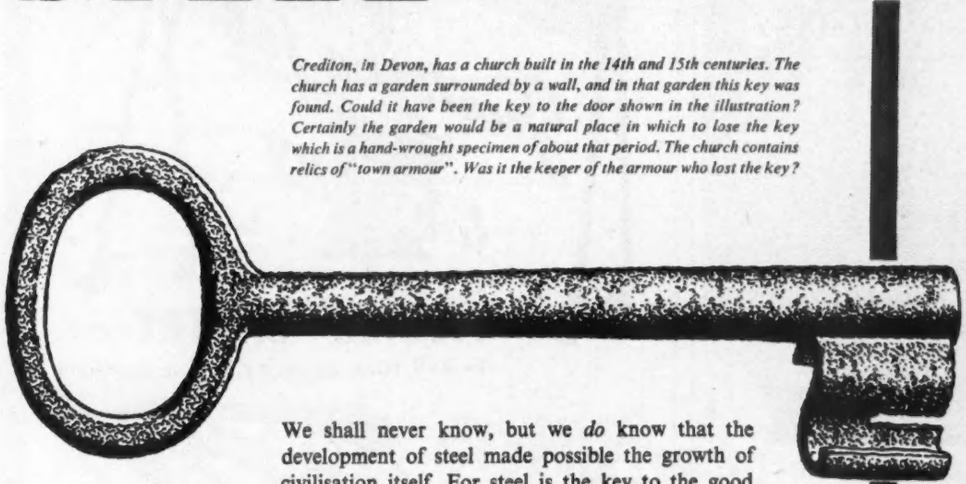

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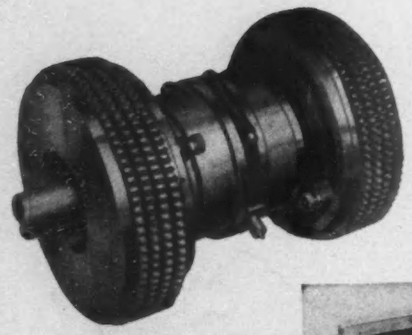

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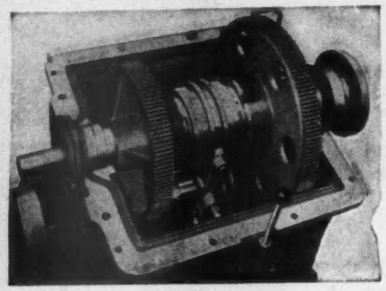

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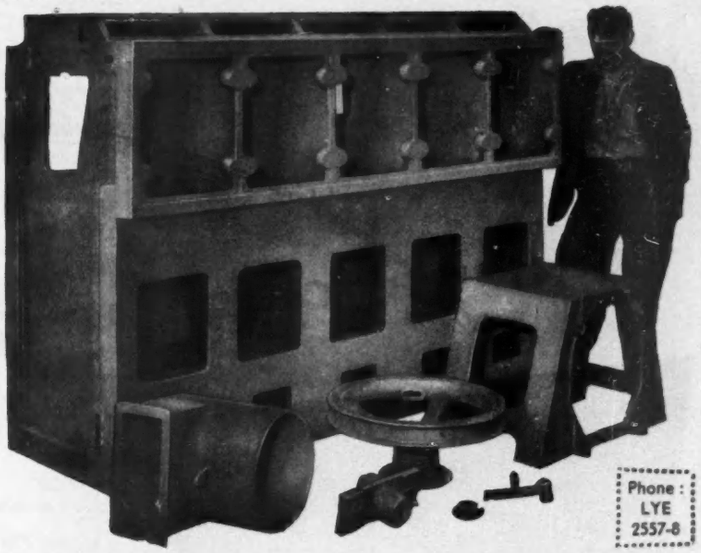

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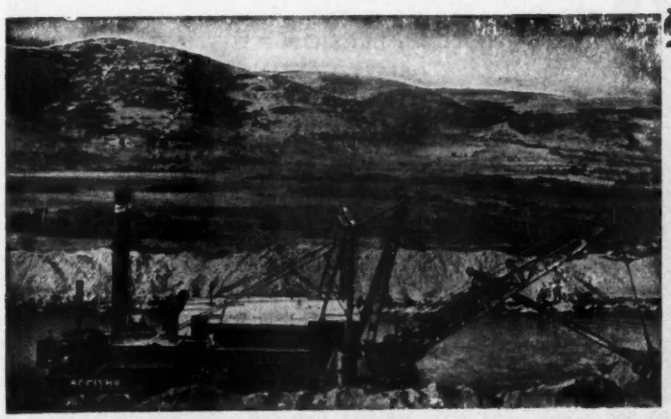

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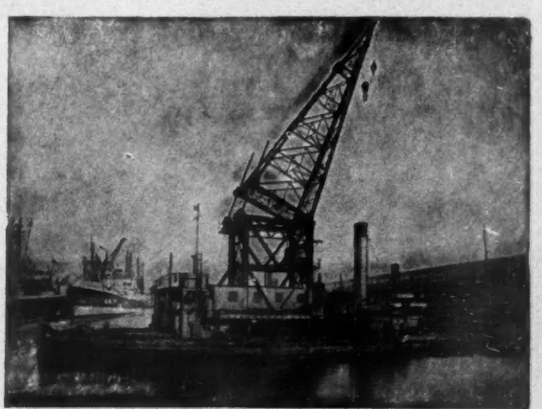

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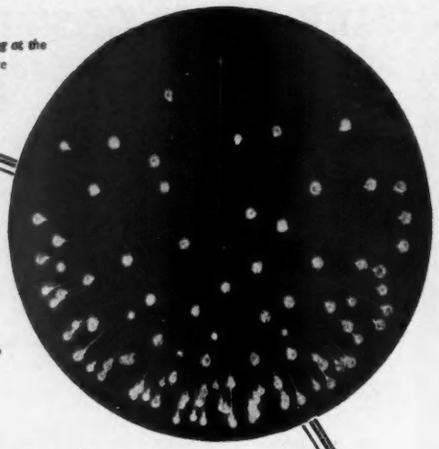

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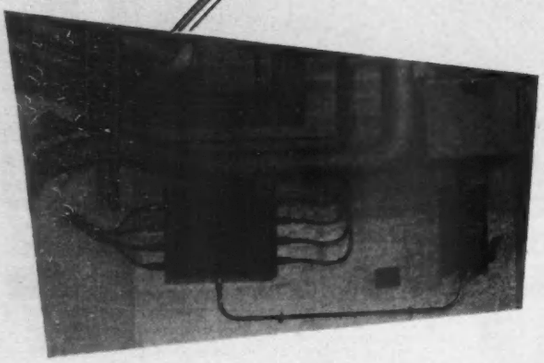

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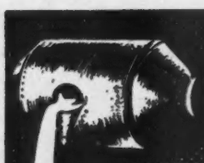

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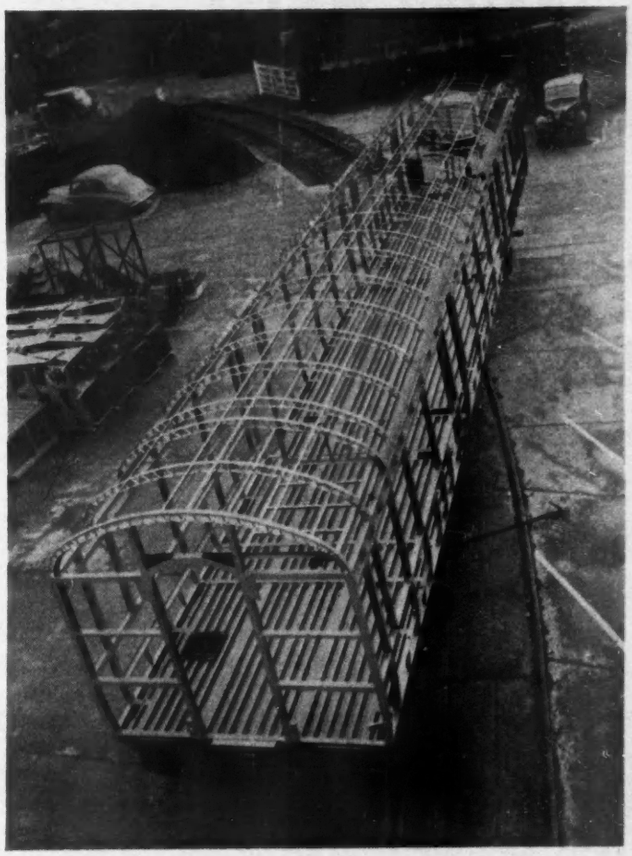

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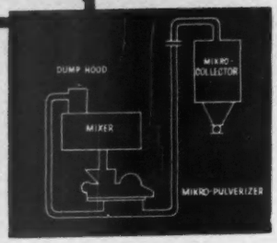


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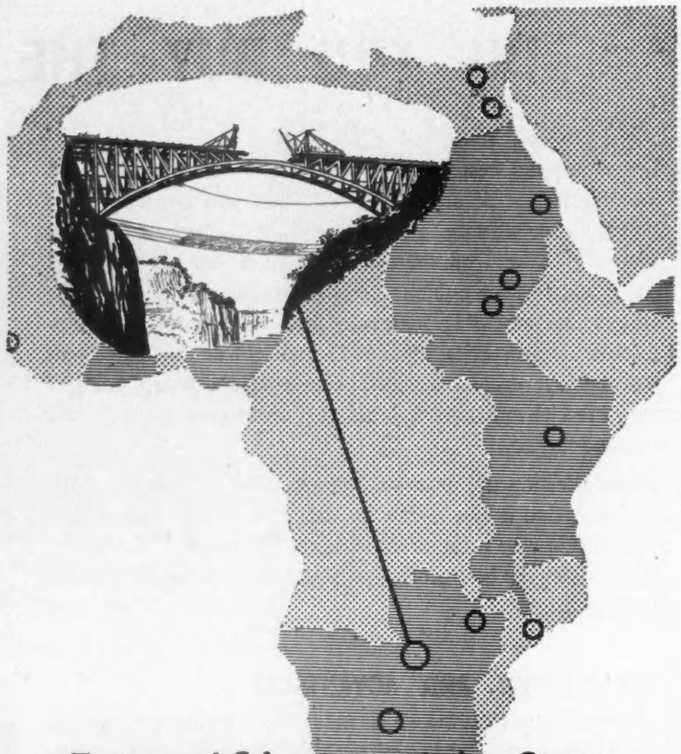

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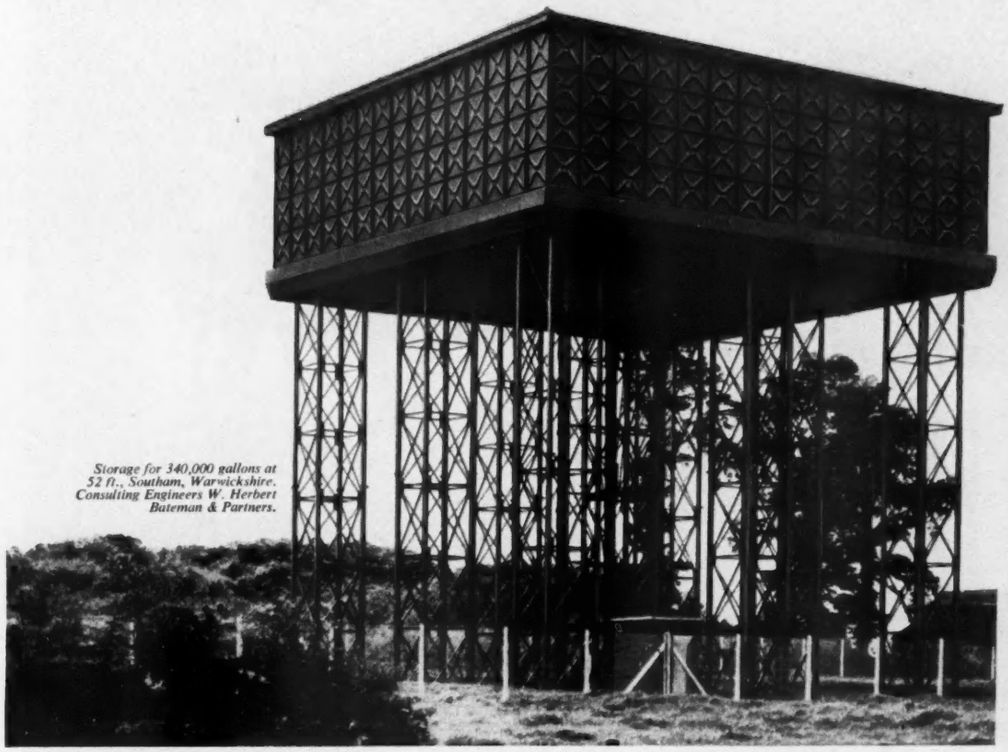

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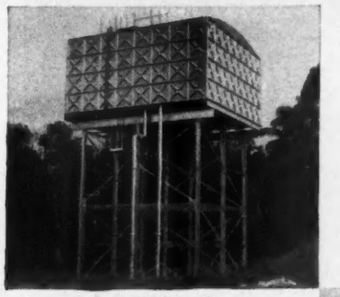

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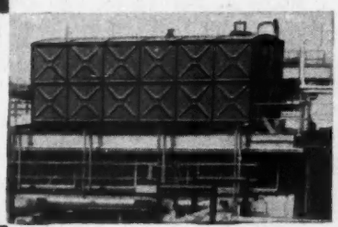
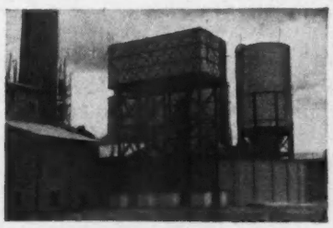
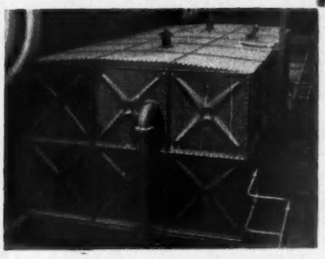


*Supported on steel grillages, one of many covered tanks erected at a power station near London. Consulting Engineers Merz & McLellan.*





*Storage tank for softened water at the Isle of Grain Oil Refinery. (Photograph courtesy Tothill Press Ltd).*

*Industrial development, Malaya. Water storage tank at the new works of Malayan Cement Ltd.*

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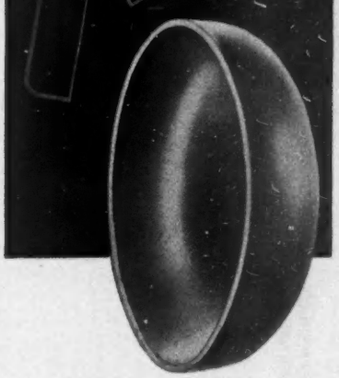

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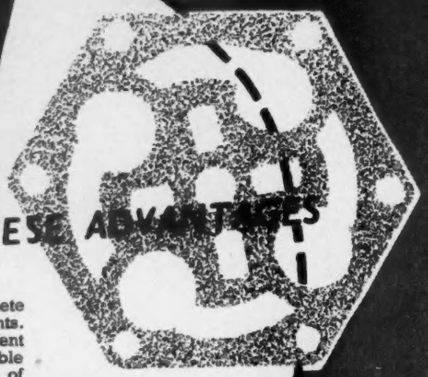

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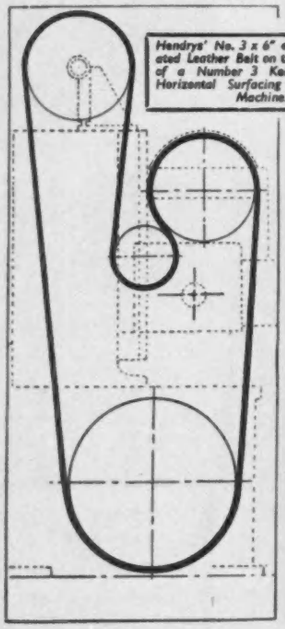

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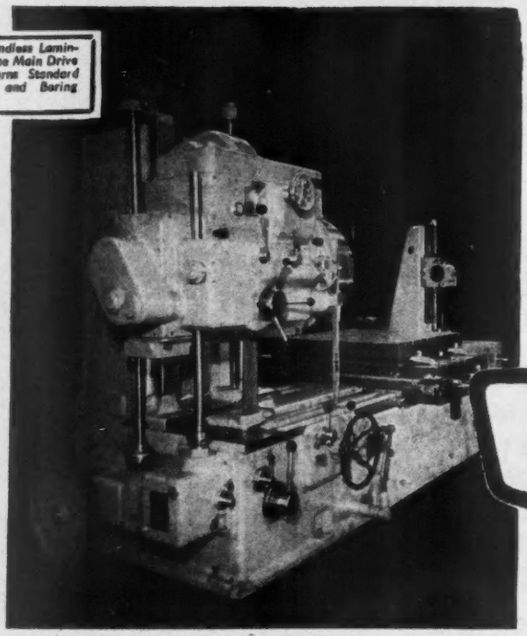

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| No. 4. | ⅝ | in. | ,, | ,, | ,, |
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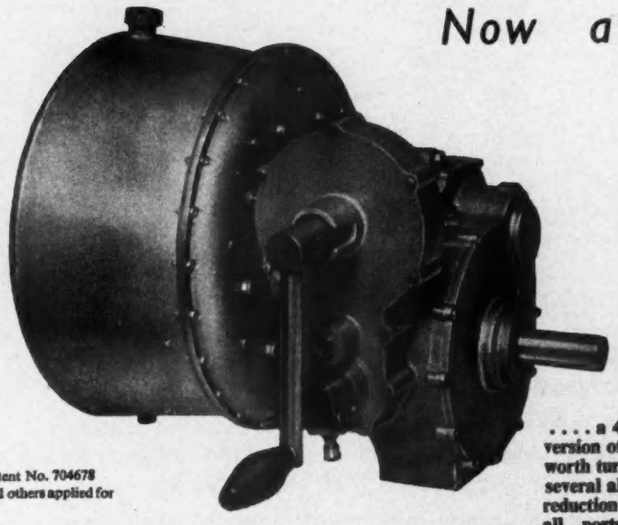

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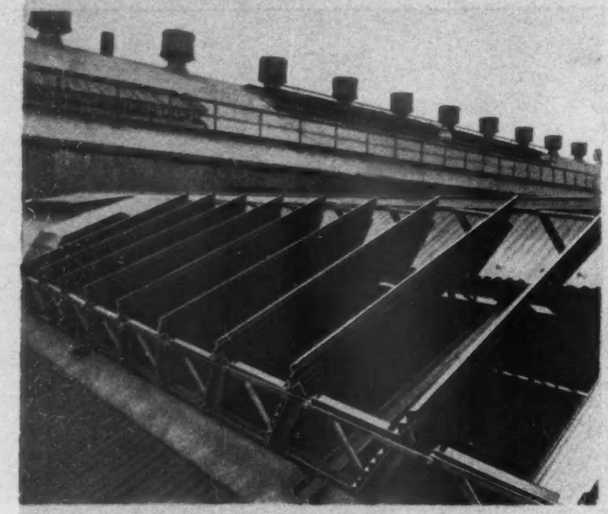
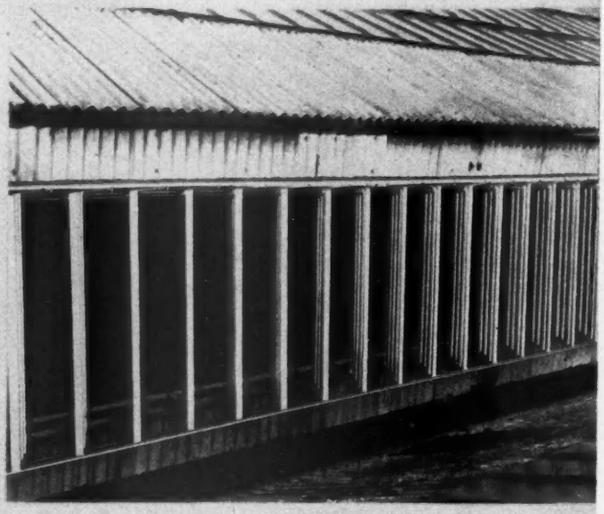
DAVID BUDWORTH LTD. - ENGINEERS - HARWICH - ESSEX - TEL 116

# Four methods of improved factory ventilation



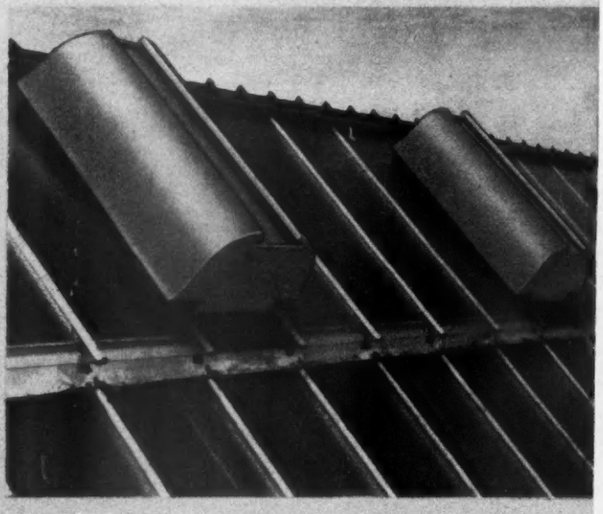
HILLS ROOF VENTILATING SHUTTERS



HILLS VENTILATING SHUTTERS -VERTICAL WALL APPLICATION

HILLS WALL-TYPE AIR INLET VENTILATORS

HILLS STACK ROOF VENTILATORS



HILLS Industrial Ventilators are designed to meet every requirement for efficient and economical ventilation in foundries, rolling mills, factories, workshops, etc. They provide positive and rapid extraction of smoke, fumes, steam and overheated air, and admit the fresh air essential to improve working conditions. All types of HILLS Industrial Ventilators are easy to install in new or existing buildings. For expert advice on any problem of industrial ventilation, we invite you to consult our Technical Advisory Department. Illustrated literature is available on request.

## HILLS Ventilation

HILLS (WEST BROMWICH) LTD., ALBION ROAD, WEST BROMWICH. (WEST BROMWICH 1811 (15 LINES)). LONDON: CHAPONE PLACE, DEAN STREET, W.1. (GERRARD 0526/9)
*Branches at Birmingham (Midland 5175), Manchester (Blackfriars 3382/3), Bristol (24765), Newcastle-on-Tyne (59081), Glasgow (City 5564).*

# CLASSIFIED ADVERTISEMENTS

**AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS**

**Lineage Rate.** 4/- per line of approximately 6 words. Minimum 16/-.

**Inch Rate.** 48/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

**AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING**

**Lineage Rate.** 3/6 per line of approximately 6 words. Minimum 14/-.

**Inch Rate.** 42/- per single column inch and *pro rata*. 12 lines to 1 inch There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £22. ½-page £41 10s. Full page £78.

**Series Discounts.** For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

**Run-On and Semi-Displayed Styles.** Both these styles are available for single column width advertisements of any depth up to 12 inches.

**Displayed and Illustrated Styles.** The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

**Use of Box Number.** 2/- which includes forwarding of replies.

**Copy Dates.** "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

*Advertisements for publication should be addressed to:*—**Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

*Urgent advertisements may be telephoned to* CENtral 6565.

## PUBLIC APPOINTMENTS

### HUDDERSFIELD COLLEGE OF TECHNOLOGY

Principal: Dr. W. E. SCOTT, M.B.E.

#### DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING

#### ASSISTANTS

Applications are invited for the following appointments, to commence as soon as possible.

Grade "B" ASSISTANT, to teach Mechanical Engineering subjects, mainly in City and Guilds Machine Shop Engineering Courses. Experience in machine tool design will be an advantage.

Grade "A" ASSISTANT, to teach Automobile Engineering subjects. Applicants should possess the Motor Vehicle Technicians' Certificate of the City and Guilds of London Institute and the National Craftsman's Certificate.

Good industrial and preferably some teaching experience desirable.

The salary (Burnham Scale), Grade "B" (Men), rises to a maximum of £1025 per annum. Grade "A" (Men), £900 per annum, plus allowances for graduate status (£75 or £125) and training (£25 to £75). The commencing salary will depend upon qualifications and experience and may include up to 12 increments in respect of approved service in industry.

Further particulars and forms of application, which must be returned within two weeks of the appearance of this advertisement, obtainable from the Principal, College of Technology, Queen Street South, Huddersfield.

H. GRAY,
Chief Education Officer.

20th June, 1958. E7882

### LOUGHBOROUGH COLLEGE OF TECHNOLOGY

#### DEPARTMENT OF WORKSHOP TRAINING AND PRACTICE

#### PRODUCTION AND DEVELOPMENT ENGINEER

Applications are invited for the position of PRODUCTION AND DEVELOPMENT ENGINEER at a salary according to the scale £1200 by £30 to £1350 p.a. The commencing salary will be determined by qualifications and experience. The successful applicant will be responsible for the training of students in the design of new products, the improvement of existing designs and the testing of finished products in the Engineering Workshops, in which the Department gives comprehensive practical training to full-time engineering students. The products include gas engines, steam engines, hydraulic testing machines and a wide range of engineering laboratory apparatus.

Applicants should be Mechanical Engineers who have had good practical training and industrial experience. They should be well qualified, and teaching experience, though not essential, is desirable.

The post is pensionable. Application forms and further particulars may be obtained from The Registrar, to whom completed applications should be sent as soon as possible (in reply please quote 22/C). E7898

### WEST SUSSEX COUNTY COUNCIL

#### CRAWLEY COLLEGE OF FURTHER EDUCATION

#### LECTURER

Applications are invited for the post of SENIOR LECTURER IN PRODUCTION ENGINEERING. Applicants should have a sound knowledge of modern engineering manufacturing processes and be competent to advise on equipping and planning for Production Courses. They should hold a Degree or other qualification in the Science and Technology of Engineering Production. The post is to be filled as soon as possible.

Housing is available through the Crawley Development Corporation.

Further particulars and form of application from the Director of Education, County Hall, Chichester, on receipt of a stamped, addressed envelope and should be returned to the Principal, Crawley College of Further Education, College Road Crawley, Sussex. E7861

## PUBLIC APPOINTMENTS

### CITY OF NOTTINGHAM EDUCATION COMMITTEE

#### PEOPLE'S COLLEGE OF FURTHER EDUCATION

Principal: W. W. DIXON, M.Sc., A.R.I.C.

#### FULL-TIME TEACHER

Applications are invited for the post of FULL-TIME TEACHER in the Engineering Department. Applicants should have a University Degree in Engineering and/or Corporate Membership of the Institution of Mechanical Engineers, with good industrial experience.

Salary in accordance with the Burnham Technical Scale for Assistants Grade B, £650 by £25 to £1025 per annum, with additions for training, graduate qualifications and increments for industrial experience. A special allowance of £100 per annum is available to a suitable candidate.

Further particulars and forms of application may be obtained from the undersigned, to whom completed forms must be returned by 18th July, 1958.

W. G. JACKSON,
Director of Education.

Exchange Buildings,
Nottingham. E7887

### UNIVERSITY OF CAPE TOWN SOUTH AFRICA

#### TECHNICAL ASSISTANT: CIVIL ENGINEERING

There is a vacancy for a Grade I TECHNICAL ASSISTANT in the Department of Civil Engineering. The successful applicant should have workshop experience, preferably including work in a research laboratory and on maintenance of instruments and electrical and hydraulic machinery. The post is vacant from 1st January, 1959.

The salary scale is £750 by £50 to £900 per annum, plus a temporary cost-of-living allowance for a married man (at present £234 per annum).

Applications (with copies of testimonials) should state age, experience and qualifications, and give the names of two referees whom the University may consult.

Two copies of the application and testimonials should reach the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1 (from whom a memorandum giving the general conditions of appointment should be obtained), not later than 20th August, 1958. An additional copy should be sent direct by air mail to the Registrar, University of Cape Town, Private Bag, Rondebosch, Cape Town, South Africa, by the same date.

The University reserves the right to appoint a person other than one of the applicants or else to make no appointment. E7874

### NOTTINGHAM AND DISTRICT TECHNICAL COLLEGE

#### BURTON STREET, NOTTINGHAM

Principal:
D. A. R. CLARK, M.Sc. (Tech.), M.I.Mech.E.

#### ASSISTANT GRADE B IN MECHANICAL ENGINEERING

Applications are invited for the post of ASSISTANT GRADE B IN MECHANICAL ENGINEERING.

A large new building comes into use in September next for well-equipped Departments of Building and Civil Engineering, Electrical Engineering, Chemistry, Physics and Mathematics, and Mining. Increased accommodation is also available to the Departments of Mechanical Engineering, Arts and Commerce, Printing and Textiles. Research work by both staff and students is being rapidly developed.

Experience in industry, teaching and/or research desirable.

Salary in accordance with the Burnham Technical Scale as follows:—£650 by £25 to £1025 per annum. Additions for Assistants include Degree allowance of £75 per annum (or £125 for good Honours Degree), up to 3 increments of £25 for training in approved cases and incremental allowance for industrial experience after age 21, and war service.

Further particulars and form of application may be obtained from the Principal, to whom completed forms should be returned not later than 18th July, 1958. E7886

## PUBLIC APPOINTMENTS

### WALSALL AND STAFFORDSHIRE TECHNICAL COLLEGE

#### JOINT EDUCATION COMMITTEE

Principal: H. CHEETHAM, B.Sc. Hons., A.M.I.Mech.E., M.I.Prod.E.

#### ASSISTANTS

Applications are invited for the following full-time teaching appointments, the duties in each case to commence on the 1st September, 1958:—

GRADE "A" ASSISTANT IN MECHANICAL ENGINEERING

Applicants should possess a Higher National Certificate in Mechanical Engineering and be able to teach Mechanical Engineering subjects to Ordinary National Certificate standard.

GRADE "A" ASSISTANT IN MACHINE SHOP ENGINEERING

Applicants should possess a Higher National Certificate in Production Engineering or a C.G.L.I. Final Certificate in Machine Shop Engineering, and be able to teach Machine Shop Engineering to C.G.L.I. Final standard.

GRADE "A" ASSISTANT IN ENGLISH

Applicants should be qualified to teach English to full-time and part-time students in Preliminary, Ordinary National Certificate and C.G.L.I. Certificate courses.

Salaries will be in accordance with the Burnham Technical Report, 1956, viz., men £475 by £25 to £900 p.a., women £430 by £20 to £720 p.a., plus equal pay increments, with appropriate additions for qualifications and training in each case.

Application forms and further particulars may be obtained from the Principal, Walsall and Staffordshire Technical College, Wisemore, Walsall, Staffs, to whom completed application forms should be returned not later than Monday, 14th July, 1958.

V. MILLSON,
E7888 Secretary to the Governors.

### NORTH RIDING EDUCATION COMMITTEE

#### CLEVELAND TECHNICAL COLLEGE, REDCAR

#### ASSISTANT

Required for September or as soon as possible afterwards.

ASSISTANT (Grade B) for Electrical Engineering to O.N.C. level. Special responsibility allowance of £100 per annum.

Forms and particulars obtainable from me on receipt of stamped, addressed envelope. Completed forms to be returned by 14th July, 1958.

F. BARRACLOUGH,

County Hall,
Northallerton. E7908

### DEPARTMENT OF MAIN ROADS, NEW SOUTH WALES, AUSTRALIA

#### CIVIL ENGINEERS

Applications are invited from graduates (or undergraduates in their final year) in Civil Engineering of a recognised British or Irish University for appointment to the staff of the Department of Main Roads, New South Wales, the State Road Authority for construction of roads and bridges.

On appointment, applicants may be engaged at the Department's Head Office, Sydney, on the design of reinforced concrete and steel bridges, or on main road construction and maintenance either in the Metropolitan Area or the country.

Commencing salary according to qualifications and experience will be within the range £A1147 to £A1353 per annum, with annual progression, subject to technical competence to £A1879 per annum. Appointees will be eligible to contribute to the State Superannuation Fund after six months.

Appointee's full fare from England to Australia will be met by the Department, subject to a three years' service guarantee bond being completed. Appointment will be subject to passing a medical examination and preference will be given to applicants not more than 30 years of age.

Applications should be made on forms obtainable from the Agent General for New South Wales, 56, Strand, London, W.C.2. E7857

## PUBLIC APPOINTMENTS

### NORTHERN GAS BOARD

#### TEES-SIDE DIVISION

#### TECHNICAL ASSISTANT—STOCKTON

Applications are invited for the position of TECHNICAL ASSISTANT at Stockton Unit.

Experience in Drawing-Office and/or Laboratory is essential.

The grading for the post will be Provincial "A" Grade APT. 5/8 (£605 to £825) according to qualifications and experience. The successful applicant will be required to pass a medical examination and join the Board's Pension Scheme.

Prospective candidates, who should have completed their National Service are requested to send full details of age, qualifications, and experience, together with the names of two referees, to the undersigned by first post Monday, 28th July.

JOHN W. PALLISTER,
Divisional General Manager.

Northern Gas Board,
Tees-Side Division,
Post Office Box No. 4,
Commercial Street,
Middlesbrough.

E7907 30th June, 1958.

### DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

#### BUILDING RESEARCH STATION, GARSTON, WATFORD, HERTS

#### SCIENTIFIC OFFICER

D.S.I.R. requires SCIENTIFIC OFFICER (PHYSICIST) at Building Research Station, Garston, Watford, Herts, for basic research in heat transfer/aerodynamic/convection processes occurring in heating and ventilation of buildings.

Qualifications: 1st or 2nd Honours Degree or equivalent.

Salary range: (Men) £595–£1050. Allowance for National Service and post-graduate experience. Normal prospects of promotion in mid-thirties to P.S.O. (salary range £1370–£1950).

Forms from M.L.N.S. Technical and Scientific Register (K), 26, King Street, London, S.W.1 (quote A.139/8A). E7864

### NATIONAL COAL BOARD

#### NORTH EASTERN DIVISION

#### JUNIOR ASSISTANT

JUNIOR ASSISTANT required in the Area Civil Engineer's Branch at No. 3 (Rotherham) Area Headquarters, salary £530–£675 per annum. The successful applicant will be required to assist in the preparation of designs of reinforced concrete and structural steel buildings, heavy industrial foundations, road and drainage works, railway works, and other heavy engineering projects in the Area Civil Engineer's Department, associated with colliery reconstruction. A qualification in either Building or Civil Engineering preferred and a knowledge of the theory and practice of the above subjects desirable.

Apply to Area Staff Manager, No. 3 Area, Wath-on-Dearne, Nr. Rotherham, by July 7th, 1958. E7872

### MINISTRY OF SUPPLY

#### LONDON

#### CIVIL ENGINEER, ARCHITECT OR SURVEYOR

Ministry of Supply require CIVIL ENGINEER, ARCHITECT or SURVEYOR in London to assist in design and planning of Civil Engineering Services for large factories and ancillary buildings, including water services, drainage, roads and allied civil engineering works. Qualifications: British of British parents. Thorough training in civil engineering. Corporate Member of Institution of Civil Engineers, or have equivalent qualifications. Applicants with exemptions from Parts I and II (Finals) may be considered. Practical experience of some of the specified duties. Salary: £805 (age 25) to £1250 p.a.—Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting E.250/8A. Closing date 29th July, 1958. E7890

**Classified Advts. continued on page 120**

## PUBLIC APPOINTMENTS

### DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

#### BUILDING RESEARCH STATION, GARSTON, WATFORD

#### SENIOR SCIENTIFIC OFFICER OR SCIENTIFIC OFFICER

D.S.I.R. SENIOR SCIENTIFIC OFFICER OR S.O. required at Building Research Station, Garston, Watford, to work as member of team on problems concerning earth pressures on tunnel linings and on earth retaining structures. Duties include field work together with background laboratory research, instrument development and theoretical analysis. Qualifications : 1st or 2nd Class Honours Degree in Civil Engineering or equivalent, and experience in either research or in practical Civil Engineering works. Men's Salary ranges : S.O. £595–£1050. S.S.O. (minimum of 3 years post graduate experience) £1130–£1330. Normal prospects of promotion in mid-thirties to P.S.O. (£1370–£1950) with prospects of higher posts. (Women slightly less.)—Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting E.238/8A. Closing date 26th July, 1958. E7841

### HERTFORD GROUP HOSPITAL MANAGEMENT COMMITTEE

#### SENIOR ENGINEER

SENIOR ENGINEER required for the Hertford Sub-Group of Hospitals. Preference given to candidates holding a First Class Certificate of Competency in Marine Engineering (or equivalent Naval Certificate) or City and Guilds Full Technological Certificate in Plant Engineering (First Class).

Applicants should have completed an apprenticeship in Mechanical Engineering, or have acquired a thorough practical, mechanical engineering training. They must have a sound knowledge of efficient operation of steam boiler plants and wide experience in a supervisory position of mechanical and electrical engineering services as found in Institutions.

The person appointed will be responsible to the Superintendent Engineer and will be required to assist in supervision of general building and maintenance work.

Salary scale £655 by £25 (5) to £780. The post is superannuable. The successful applicant will be required to live at, or reasonably close to, Hertford. No accommodation provided.

Applications stating age, qualifications, experience, with names of two referees, to Group Secretary, Hertford County Hospital, Hertford, Herts, by 9th August, 1958. E7897

### PUBLIC WORKS DEPARTMENT

#### ADEN

#### MECHANICAL AND ELECTRICAL ENGINEER

To supervise the Department's workshops and garage dealing with operating, maintenance and overhaul of civil engineering mechanical plant and equipment, including refrigeration.

Contract appointment for 18–24 months in the salary range £1032 to £1929 per annum with a gratuity of from £25 to £37 10s. 0d. per quarter on satisfactory completion of contract. Entry point according to experience. Furnished quarters with refrigerator at low rental. Free medical attention and free passages for the officer, his wife and up to four children under 18. Allowance for education of children outside Aden.

Candidates should be A.M.I.Mech.E. and have had not less than seven years' training and practical experience. An electrical engineering qualification and experience with refrigerating equipment will be an advantage.

Write, Director of Recruitment, Colonial Office, S.W.1, stating age, qualifications and experience. Quote BCD 112/2/018. E7900

### DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

#### BUILDING RESEARCH STATION, GARSTON, WATFORD

#### STRUCTURAL OR CIVIL ENGINEERS

D.S.I.R. STRUCTURAL OR CIVIL ENGINEERS with a Scientific outlook, required at the Building Research Station, Garston, Watford, to work on research projects relating to nuclear power stations, multi-storey buildings, lightweight reinforced concrete or ultimate strength design. Work includes laboratory investigations, field studies and collaboration with engineering consultants and contractors. Posts are in S.O./S.S.O. range. Qualifications : 1st or 2nd Class Honours degree in Civil Engineering, or equivalent. Men's salary ranges, S.O. £595–£1050. S.S.O. (minimum of 3 years post graduate experience) £1130–£1330 (men). Normal prospects of promotion in mid-thirties to P.S.O. (£1370–£1950) with prospects of higher posts. (Women slightly less.)—Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting E.239/8A. Closing date 26th July, 1958. E7842

## PUBLIC APPOINTMENTS

### CENTRAL ELECTRICITY GENERATING BOARD

#### EASTERN DIVISION

Applications are invited for the following appointment :

SECOND ASSISTANT MAINTENANCE ENGINEER (MECHANICAL)—LITTLE BARFORD GENERATING STATION

Salary Class G, Grade 10, £790 by £15 to £835 per annum, eventually rising to Class J, Grade 10, £885 by £15 to £930 per annum.

Applicants should have served an apprenticeship, possess suitable technical qualifications and have had experience in the maintenance of the mechanical plant in a large modern Generating Station.

Applications, quoting Reference No. 2/9361, stating age, qualifications, experience and present position, should be sent to the Controller, Central Electricity Generating Board, Eastern Division, West Farm Place, Chalk Lane, Cockfosters, Barnet, Herts, by 12th July, 1958.

W. N. C. CLINCH,
E7846 Controller.

### ROYAL SCOTTISH MUSEUM, EDINBURGH

#### ASSISTANT KEEPERS

Two pensionable posts of ASSISTANT KEEPER (1) in department of technology (2) in department of natural history. Appointment in post (1) to Grade I or Grade II depending on age and experience. Age : for Grade II at least 21 and under 26 on 1st August, 1958 : extension for service in H.M. Forces, Overseas Civil Service, established Civil Service (up to two years) or exceptional qualifications ; for Grade I, normally at least 30 on 1st August, 1958. Qualifications : candidates must have, or obtain in 1958, for post (1) first or second class honours degree in engineering or technology, with workshop or equivalent practical experience ; for post (2) first or second class honours degree in zoology. Duties in post (1) include supervision of engineering workshops and preparation of technological exhibits ; in post (2) detailed work in bird or insect collections, maintaining study collections and arranging exhibitions. Starting salary (Grade II) £615 (or higher). Scale maximum (men) £875. Grade I salary scale (men) £1145–£1800. Promotion prospects.—Write Director, Royal Scottish Museum, Chambers Street, Edinburgh, 1, for application form. Closing date 31st July, 1958. E7847

### DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

#### BUILDING RESEARCH STATION, CRAWFORD STREET, LONDON, W.1

#### CIVIL ENGINEER

D.S.I.R. requires CIVIL ENGINEER (Basic Grade) at Building Research Station, Crawford Street, London, W.1, for investigations into operational and organisational problems associated with building techniques, as part of study of building processes. Candidates should have obtained, or be qualified by examination for admittance to, Corporate Membership of the Institution of Civil or Structural Engineers or have a 1st or 2nd Class Honours degree in Engineering, and be interested in application of scientific method to day-to-day problems facing building industry. Experience with building and civil engineering contractors an advantage. Men's Salary range £805 (age 25) to £1250.—Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting E.592/7A. Closing date 26th July, 1958. E7843

### CITY OF BRADFORD

#### ENGINEERING ASSISTANTS

Applications are invited for the appointment o ENGINEERING ASSISTANTS on Special Grade (£750–£1030) ; commencing salaries in accordance with experience and qualifications. These posts are superannuable.

Candidates should preferably hold an Engineering Degree, be A.M.I.C.E./A.M.I.Mun.E., and have had good general civil engineering training.

Applicants should have completed their National Service.

No housing accommodation can be provided by the Corporation.

Applications (quoting Post Nos. 18, 119, 175, 202) on form to be obtained from the City Engineer, Town Hall, Bradford, 1, together with three testimonials, must be received by the undersigned by 31st July, 1958.

W. H. LEATHEM,
Town Clerk.
Town Hall, Bradford, 1. E7832

### BUCKS WATER BOARD

#### DIESEL AND PUMP FITTER

A keen, young, experienced FITTER is required to carry out and supervise the Board's fitting work to the Instructions of the Pumping Stations Superintendent.

The salary scale is £625–£745 on Misc. Div. Grades V/VI, with a starting rate dependent on experience, and the applicant will be required to join the superannuation scheme.

A semi-detached house is available (with garage if required) at a reasonable rent at a site on an hourly bus route three miles from Chesham and one hour from London.

Applicants should apply immediately to the undersigned.

R. POWNALL,
Pebble Lane, Engineer and Manager.
Aylesbury. E7891

## PUBLIC APPOINTMENTS

### ATOMIC ENERGY RESEARCH ESTABLISHMENT HARWELL

## ENGINEERS

to be responsible to senior engineer for modification, running and maintenance of major research equipment of a unique type. Training will be given in special techniques required.

Engineering apprenticeship and Corporate Membership of Engineering Institution or equivalent training and qualifications essential. Knowledge of basic electrical engineering practice, high vacuum techniques or electronics desirable.

Salary in range £815–£1740. Housing, superannuation.

Send POST CARD to Group Recruitment Officer (1154/25), A.E.R.E., Harwell, Didcot, Berks., for application form and details.

E7876

### STRUCTURAL ENGINEERING DRAUGHTSMEN

required by

### MINISTRY OF WORKS

for employment in London, Scotland and Provinces on design and detailing of reinforced concrete or structural steelwork.

SALARY RANGE £550 (age 21) to £870 p.a., London (slightly less elsewhere). 5-DAY WEEK. 3½ WEEKS' ANNUAL LEAVE INITIALLY.

STARTING PAY ACCORDING TO AGE, QUALIFICATIONS AND EXPERIENCE.

GOOD PROSPECTS OF PROMOTION WITH SALARIES OF £1015 p.a. AND ABOVE.

OPPORTUNITIES FOR PERMANENT POSTS LEADING TO PENSIONS (NON-CONTRIBUTORY).

Possession of O.N.C. or equivalent an advantage.
Interviews at Regional Offices where possible.

APPLICATIONS.—State age, training and experience to Chief Structural Engineer, Ministry of Works, Room 404, Abell House, John Islip Street, S.W.1.

E7717

## U.K.A.E.A.

## NUCLEAR RESEARCH ENGINEERS

### The Nuclear Research Division, Aldermaston

has vacancies for Engineers, who will work with Scientists, in the following fields.

### CONTROLLED THERMONUCLEAR REACTIONS

The design and construction of low inductance condenser bands of considerable magnitude for use in experiments in ultra-high-current gas discharge.

### PARTICLE ACCELERATORS

The design of experimental apparatus for Nuclear Physics Research encompassing large vacuum chambers, large magnets, ion sources and associated beam focussing devices.

The Establishment has in current use accelerators ranging from 800kV. to 6MV. and is developing additional larger machines.

### REACTORS AND NUCLEAR ASSEMBLIES

Mechanical design effort to produce equipment to handle large masses of fissile material, including apparatus to provide intense bursts of fast neutrons. Also the design of ancillary equipment for research reactors.

### GENERAL NUCLEAR ENGINEERING

The control of a Research Reactor ; Loop Studies with a Research Reactor ; and novel pulsed reactor design.

**The appointments are at various levels, depending on ability and experience, but all candidates must have served a recognised engineering apprenticeship, and must be Corporate Members of one of the Senior Engineering Institutions, and should have had several years' experience of engineering design work, preferably in the electro-mechanical field.**

**SALARY will be assessed within the range £815 - £2080.**

Contributory Superannuation scheme. A house or assistance towards legal expenses on house purchase will be available for married officers living beyond daily travelling distance.

*POSTCARDS for application forms to the Senior Recruitment Officer at above address. Please quote ref.* 1879/25.

E7896

## PUBLIC APPOINTMENTS

GOVERNMENT OF THE FEDERATION OF MALAYA

### CIVIL ENGINEERS

are required for the Drainage and Irrigation Department on contract for 3 years.

Qualifications: Corporate members of the Institution of Civil Engineers or have passed (or hold qualifications which exempt them from) Parts I and II of the A.M.I.C.E. Examination. In addition they must have at least two years' practical experience of civil engineering construction, preferably including experience with heavy earth-moving mechanical plant or the design and construction of reinforced concrete works. Minimum age 26.

Basic Salary—$628 by 34–934/982 by 34–1254 p.m. (£879 by 47–£1307/£1374 by 47–£1755 p.a.).

Increment credits given for experience. In addition, Expatriation and Cost of Living Allowances are payable. Substantial Gratuity on completion of contract, full pay Vacation leave, free passages, free medical attention (except for a small charge for maintenance in a hospital).

Further details and application forms may be obtained from the Recruitment and Personnel Division, Dept. E.2, Malaya House, 57, Trafalgar Square, London, W.C.2. E7884

GOVERNMENT OF THE FEDERATION OF MALAYA

Civil Engineers for the Public Works Department are required on 3-year contract. Qualifications: (*a*) A.M.I.C.E. or (*b*) a Degree or Diploma of a University or Engineering College recognised by the Institution of Civil Engineers as granting exemption from Parts I and II of the Institution of Civil Engineers Examination; plus two years of approved practical experience in engineering, or (c) Pass in Parts I and II of the Professional Examination of the Institution of Civil Engineers, after at least a three-year course at a recognised College or after at least three years' training as an articled pupil or apprentice; plus two years' approved practical experience in engineering.

Age minimum 26—maximum 40.

Basic Salary $628 by 34–934/982 by 34–1254 p.m. (£879 by 47–£1307/£1374 by 47–£1755 p.a.). Increment credits given for experience. In addition Expatriation and Cost of Living Allowances are payable. Substantial Gratuity on completion of contract, full pay Vacation leave, free passages, free medical attention (except for a small charge for maintenance in a hospital).

Further details and application forms can be obtained from the Recruitment and Personnel Division, Dept. E1, Malaya House, 57, Trafalgar Square, London, W.C.2. E7885

## TENDERS

### COUNTY BOROUGH OF BRIGHTON

#### WATERWORKS DEPARTMENT

#### MILE OAK PUMPING STATION

TENDERS invited for MANUFACTURE, DELIVERY, ERECTION, TESTING and MAINTENANCE of THREE ELECTRICALLY-DRIVEN SUBMERSIBLE WELL PUMPS and FIVE BOOSTER PUMPS with Control Gear and other Appurtenant Works.

Specification and particulars from Waterworks Engineer, 12, Bond Street, Brighton, 1, on payment of five guineas deposit, to be refunded on receipt of a bona-fide Tender and return of all documents.

Tenders, in plain, sealed envelopes, endorsed "Tender for Pumping Plant, Mile Oak," to be delivered to me by noon on 23rd August, 1958.

The Corporation do not bind themselves to accept the lowest or any Tender.

W. O. DODD,
Town Clerk.

Town Hall,
Brighton, 1.
June, 1958.

E7875

## EDUCATIONAL

**A.M.I.MECH.E., B.Sc.,** City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent. successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114

## SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

**A TECHNICAL ASSISTANT** for the Works Director is required by a medium-sized precision engineering company in Surrey. Applicants should be qualified Production Engineers aged 35 to 45 years, and possess either B.Sc. (Eng.) or A.M.I.Mech.E. Practical commercial experience is essential. Salary, £1200 to £2000, according to age and experience. The prospects for the right man are very good. Applications, which will be treated in strict confidence, should give the fullest details of career, health and present occupation.—BOX No. E1960, "The Engineer." A

**A WELL-KNOWN GENERAL ENGINEERING COMPANY** in the North West of England, a subsidiary of a world-renowned American concern, is about to appoint an EXECUTIVE INDUSTRIAL ENGINEER, responsible to the General Works Manager, to take complete charge of the Process Planning, Ratefixing, Jig and Tool and Production Control Departments. Candidates, who must have top-class knowledge in methods and industrial engineering, will be expected to have had experience in works management. In addition to his normal duties, the successful candidate will require to advise management on the purchase of machines and tools, and a certain amount of travel in this country and abroad will therefore be necessary. Please reply, stating age, qualifications, experience, salary required and present salary.—BOX No. E7869, "The Engineer." A

**AN EXPANDING WEST MIDLANDS ENGINEERING FIRM** needs a young Accountant at about A.C.W.A. or A.C.I.S. level. The post carries a high salary, is progressive and pensionable. Practical experience of manufacturing accounts and systems essential.—Apply giving full details to BOX No. E7904, "The Engineer." A

**AN EXPERIENCED DRAUGHTSMAN-DESIGNER**, required for rapidly expanding Engineering organisation. Used to modern methods of plant layout, initiation of special purpose machinery, conveyorisation, boiler house practice and usual factory ancillary services. This post calls for a man of ability to translate production needs efficiently and offers a progressive future. Age 25–45 years. Apply in first instance, stating technical qualifications, experience, and salary required.—BOX No. E1965, "The Engineer." A

**AN OPPORTUNITY EXISTS FOR AN ENGINEER** in the Export Department of a well-known Boiler Manufacturer in Scotland. Required to travel abroad two to three months annually on sales matters, visiting Agents and Clients. Age 30/40. Knowledge French and/or Spanish desirable but not essential. Applicants should indicate both their technical qualifications and engineering experience as well as salary required.—BOX No. E1958, "The Engineer." A

**APPLICATIONS ARE INVITED** from DESIGN DRAUGHTSMEN with experience in paper and board conversion and/or packaging machinery and equipment. The salary offered will be in keeping with qualifications and experience and the prospects are excellent. Please write in confidence, giving details of qualifications, experience, age and salary expected. —BOX No. E7877, "The Engineer." A

**APPLICATIONS ARE INVITED** for the following appointment at the CLAYDON, SUFFOLK, Works of THE BRITISH STEEL PILING CO., LTD.

SENIOR DESIGNER DRAUGHTSMAN (Minimum qualifications H.N.C. or equivalent).

Age group 28–35 years. Candidates should be capable of accepting responsibility for complete projects.

THIS APPOINTMENT IS PERMANENT AND PROGRESSIVE IN AN EXPANDING ORGANISATION and the successful candidate will be engaged on interesting work in connection with special crane type structures, hoisting machinery (steam, diesel, electric) and contractors' plant.

Contributory pension scheme in operation. Good canteen facilities. Salary in accordance with qualifications and experience. Holiday arrangements respected. The Works are situated 15 minutes bus ride from the centre of Ipswich.—Applications to the Personnel Officer at the above address. E7711 A

**APPLICATIONS** are invited for the post of SALES ENGINEER for the London office of an old-established company, which is anxious to explore new fields within the scope of heavy steel plate work and high-duty mechanical transporting plant, with special emphasis on export. Applicants should possess good initiative and have had previous sales experience for both home and foreign markets. The position is pensionable and carries excellent prospects. Preferable age about 35. Please give full details of experience and salary required.—BOX No. E1970, "The Engineer." A

**ASSISTANT ENGINEER** required, aged 27/33. Should be conversant with steam raising, refrigeration and transport. Previous brewery experience an advantage but not essential.—Apply in writing, stating qualifications and present salary, to Manager, Truman's Brewery, P.O. Box No. 10, Derby Street, Burton upon Trent. E1977 A

**ASSISTANT ENGINEERING LECTURER** required for Cadet Training Course on modern refrigerated cargo motor liner fitted out for the purpose plying between the United Kingdom and Australia or New Zealand. In conjunction with the Senior Lecturer in charge, duties will include the teaching of thirty cadets (in two classes) studying on a two-year course for Part I of the Engineering Institutes Examination, and applicant will also be expected to take part in the social life of the officers and cadets, both ashore and afloat. The applicant should be not more than 40 years of age, have graduate qualifications and at least four years' teaching experience in a technical college or similar institution. Full pension facilities available.—Apply to the Superintendent Engineer, New Zealand Shipping Co., Ltd., Royal Albert Dock, London, E.16, giving usual particulars, experience, &c., and state salary required, before July 16th, 1958. E7450 A

#### BLAST FURNACE ENGINEER

Engineering Company situated in the North West require the services of a first-class Blast Furnace Engineer. The position affords an excellent opportunity to quickly attain the status of Manager, with full responsibility for this sphere of the Company's operations. For this reason, applicants must be suitably qualified and have had not less than 10 years' industrial experience of Design and Estimating. The ability to deal directly with customers' requirements would be an added advantage. An excellent salary, together with pension rights, will be offered to the successful applicant.—BOX No. E7878, "The Engineer." A

**COMPETENT DESIGNER-DRAUGHTSMAN** to train as Contracts Engineer. Excellent prospects for draughtsman with interest and experience in mechanical engineering and light plate work.—Apply, in confidence, to Dust Control Processes, Limited, P.O. Box No. 60, Kingston-upon-Thames, Surrey. E1971 A

**DESIGN DRAUGHTSMEN** required for Mechanical Design of Nucleonic Instruments. Pleasant working conditions. Excellent rates of pay.—Apply, Chief Draughtsman, Isotope Developments, Ltd., Beenham Grange, Aldermaston, Berks. (Tel.: Woolhampton 451). E7862 A

**DEVELOPMENT AND PRODUCTION EXECUTIVE** required to advise and supervise production of aluminium articles. Should be expert in fabrication and uses of aluminium and its alloys, including finishing techniques involved. Send full details of qualifications, experience and present salary.—BOX No. E1969, "The Engineer." A

**DRAUGHTSMAN** required for Development work on special purpose machinery. Wide knowledge of mechanisms essential. Applicants should be aged 21/25 years and have O.N.C. 5-day week. Sick and pension fund.—Apply in writing to Personnel Officer, Osram Glass Works, East Lane, North Wembley. E124 A

#### DRAUGHTSMAN

Lancashire Tar Distillers, Ltd., require a Senior Draughtsman for their Engineering Department.

The work is varied and interesting, covering the installation of and modifications to plant in the various works of the company.

Some site work would be involved.

A pension scheme is in operation and a canteen available. Any holiday arrangements made previously would be honoured. Applicants should preferably be of at least O.N.C. standard, with experience of plant layout and pipework, but all applications would be considered.

All applications will be treated with confidence.

Applications, stating age, qualifications and experience, should be sent to Chief Engineer, Lancashire Tar Distillers, Ltd., Liverpool Road, Cadishead, Nr. Manchester. E7821 A

**DRAUGHTSMEN.**—Senior Material Handling and Structural men with at least ten years' experience in either field. Vacancies in our London and Bromley offices. Bonus and pension schemes. Holidays will be honoured.—Reply to JOHN WILSON & CO. (ENGINEERS), LTD., 30A, Widmore Road, Bromley, Kent. E1959 A

#### DRAUGHTSMEN

Experienced Draughtsmen required, used to design of colliery and/or mechanical handling equipment. Good opportunities and permanent situation available.—Apply in writing, stating age, experience, qualifications, &c., to:

QUALTER, HALL AND CO., LTD.,
P.O. Box 8, Railway Foundry, Barnsley.
E1967 A

**DRAUGHTSMEN,** of Senior or Intermediate grades, are required for a newly established drawing-office in the field of bakery engineering. Applications (which will be treated confidentially) are invited from men having a wide basic experience in engineering which enables them to work without close supervision. Apply in writing, giving brief particulars of education, workshop and D.O. experience, and present salary. Evening interviews can be arranged.—Chief Draughtsman, Pelkman Bros., Ltd., 41, Buckingham Palace Road, London, S.W.1. E1972 A

**ELECTRICAL DRAUGHTSMAN.**—The Stanton Ironworks Company, Limited, Near Nottingham, has a vacancy for an Electrical Draughtsman with experience in planning schemes for lighting and power distribution and preparation of wiring diagrams for motors, control gear, &c., as applied to heavy industrial practice. The post is pensionable. 5-day week. Holiday arrangements honoured.—Write in confidence to the Staffing Officer, stating age, qualifications and experience. E7881 A

**ELECTRICAL OR MECHANICAL ENGINEER** wanted by large German company for German-English translations. Applications are invited from British-trained engineers with a good knowledge of German who have an inclination towards translation work and desire to work in a pleasant environment in Germany for at least 2 to 3 years. Write, stating age, education, experience and salary.—BOX No. E1939, "The Engineer." A

**ENGINEER** required, for interesting development work in metallurgical plant, East London. H.N.C. and technical engineering standard minimum. Proficiency in Mathematics essential.—Write, BOX ZG61, Deacons Advertising, 36, Leadenhall Street, E.C.3. E7892 A

**ENGINEERING CLERK OF WORKS** required for site supervision of extensive Engineering and Electrical Reservicing Installation in existing Hospital in Bristol. Duration of contract approximately 2½ years, commencing August, 1958. Salary £750 per annum for man with at least 10 years' supervisory experience of this class of work.—Write, stating age and experience, to Messrs. Hoare, Lea and Partners, Consulting Engineers, 21, Oakfield Road, Clifton, Bristol, 8, marking envelope "Clerk of Works." E7853 A

**ENGINEER SURVEYOR** required for inspection of Cranes and other Lifting Plant. Must have drawing-office experience of design of Cranes, also National Certificate for Mechanical Engineering. Resident Glasgow or near. Salary £735 to £1060 E.S.A. scale. Non-contributory pension, etc.—Apply Manager, Eng. Dept., General Accident Corporation, Ltd., 99, Aldwych, London, W.C.2. E7902 A

**ERECTION ENGINEER.**—Suitably experienced man required to take charge of erection of aerial ropeways abroad. Excellent climate and conditions; 18 to 24 months' initial contract.—BOX No. E1968, "The Engineer." A

**FOOD PRODUCTION COMPANY** of international importance requires Graduate or young, practical and technically trained men as ASSISTANT ENGINEERS. Must be prepared to accept position in any part of the United Kingdom. Good salary, working conditions and excellent prospects of promotion. Apply, Reference I.H.C.—BOX No. E7705, "The Engineer." A

#### INSTRUMENTATION ENGINEER

British Nylon Spinners invite applications for a Graduate in Mechanical or Electrical Engineering to fill a vacancy in their head office.

Candidates, between 28–35 years of age, should have had experience in the investigation, design and application of industrial instrumentation, including pneumatic and electrical control gear.

This appointment, in an expanding and stable industry, offers a progressive and satisfying career to a man who is keen to apply his knowledge to design and installation problems and to follow a project through to its completion.

Prospects are good, whilst progress is carefully watched. A contributing pension scheme is in operation, houses may be rented and removal expenses assisted.

Selected applicants will be invited to visit the company, which is attractively situated, for a personal discussion.

Applications, quoting Ref. 27, should be made to the Personnel Manager, British Nylon Spinners, Ltd., Pontypool, Monmouthshire. E7830 A

**INSTRUMENT MAKER,** Elcectrical and Mechanical, required. Applicants should be fully conversant with the maintenance of all modern industrial instruments and capable of making and testing such apparatus. Excellent prospects for advancement. Please write, giving full particulars of experience and age.—BOX No. E7867, "The Engineer." A

**JUNIOR PRODUCTION ENGINEER** for progressive organisation. Excellent prospects. Pension and insurance benefits.—Matisa Equipment Limited, Hanworth Lane, Chertsey. E1963 A

**K. S. PAUL (MOLYBDENUM DISULPHIDE), LTD.,** Park Royal Road, N.W.10, require for Technical Sales Department APPLICATION ENGINEER, to advise customers on difficult lubrication problems. London based. Applicant must be keen, energetic, loyal. Excellent prospects for advancement.—State salary, experience, age, in confidence, to Managing Director. E1974 A

**LEADING MANUFACTURERS** of Plastic and Hydraulic Plant require qualified SALES ENGINEER as Assistant in their London Office. Age 25/30 years. Commencing salary £1250 per annum. Excellent prospects of early promotion.—BOX No. E1951, "The Engineer." A

**MECHANICAL ENGINEER** required by North London Engineering Company. Experienced in design of medium-sized automatic special purpose machines. Accustomed to initiative and responsibility. Qualifications, H.N.C. or equivalent preferred. Salary from £1000 per annum, according to age and experience. Pension scheme. Apply.—BOX No. E7909, "The Engineer." A

#### NUCLEAR POWER PLANT CONTROL

A number of Graduate Control Engineers with at least three years' experience in the control field and good mathematical ability, are required to work on investigations of the control of a nuclear power station.

The work is interesting and involves all aspects of the plant: reactor, heat exchangers and turbo-alternators. It requires close team work and the ability to translate the results of theoretical studies into hardware. A knowledge of the control of conventional power stations would be an additional recommendation. An analogue computer is available and tuition will be given in its use for the solution of problems.

Please apply in writing to:
The Secretary (Ref. 11/E),
ATOMIC POWER CONSTRUCTIONS, LTD.,
28, Theobalds Road,
London, W.C.1. E7844 A

**PERA** is carrying out research to develop new metal forming and machining techniques and improve cutting tool performance. Engineers, age group 24–32, anxious to apply their technical knowledge are invited to apply for staff positions. Status and salary will depend on age, qualifications, and experience. Career details should be sent to the Secretary, PRODUCTION ENGINEERING RESEARCH ASSOCIATION, Melton Mowbray, Leics. E7906 A

#### SPERRY GYROSCOPE CO., LTD.
#### APPLICATIONS ENGINEER

This is a new appointment entailing initial contacts with customers and liaison with design and production departments concerning the sales of our expanding range of commercial products. These include hydraulic and electrical components and systems for established and novel uses in the servo control of machine tools and industrial processes.

Enquiries are invited from experienced engineers with practical workshop and D.O. experience in an industry concerned with industrial machines and electro-hydraulic control techniques. Preference will be shown to applicants also possessing academic qualifications of H.N.C. level or above and negotiating and sales experience.

This post is based at Brentford, Middlesex, but entails travelling throughout the United Kingdom.

Please write, giving details of background and experience, to Mr. R. W. H. Lubbock, Sperry Gyroscope Co., Bracknell, Berks. E7860 A

Classified Advts. continued on page 122

SITUATIONS VACANT

**SENIOR ELECTRICAL ENGINEER**

International Combustion Limited, Derby, have a vacancy for a Senior Electrical Engineer to take charge of all projects involving electrical and control gear.

Further details on request. Highest salary paid to suitable candidate.

Reply, giving full particulars, to :—
Chief Engineer,
International Combustion Limited,
Derby. E7771 A

**SENIOR MECHANICAL ENGINEERING DRAUGHTSMEN** required by engineering company in West Midlands engaged in commercial vehicle production. A background in fabrication and a knowledge of hydraulics is desirable. Several years' experience as a draughtsman is essential. The company operates an attractive life assurance and pension scheme. Salary based on age, qualifications and experience. Write, giving full personal details.—BOX No. E7895, "The Engineer." A

**STEAM TURBINES.**—Competent Design Engineers, also well qualified Design Draughtsmen, required in the Midlands to participate in a development programme embracing advanced designs of Steam Turbines in the smaller and medium size range up to 10,000kW capacity. The positions will be permanent and well paid with excellent prospects of advancement to men of the right calibre. Please write in confidence giving details of age, present salary, technical qualifications and experience.—BOX No. E7840, "The Engineer." A

**TECHNICAL ENGINEER** required as Assistant Manager for the Boiler Department of leading established engineering company. Highest technical ability and qualifications required. Age 35–45 preferred. The position is permanent with excellent prospects. Superannuation scheme, &c. Apply with full details of experience, qualifications, age and salary required.—BOX No. E7873, "The Engineer." A

**THE MOND NICKEL COMPANY LIMITED**

The Mond Nickel Company Limited invites applications for a post in a team, at its Birmingham Research Laboratory, investigating the effects of low and high temperatures upon the mechanical properties of special alloys. Both conventional and special techniques are involved. Publication of results will be encouraged.

Appropriate professional qualifications in either metallurgy, engineering or physics are preferred, but other applicants with suitable experience and providing evidence of ability to undertake research investigations with minimum supervision, will be considered.

Salary will be in accordance with experience and qualifications. Pension and assurance schemes are in operation and, in appropriate cases, assistance can be given for housing. Applications, which will be treated in confidence, should give details of age, qualifications and experience, and be addressed to the Manager, Development and Research Department, The Mond Nickel Company Limited, Thames House, Millbank, London, S.W.1. Please mark envelope "Confidential L.62." E7848 A

**THE REED PAPER GROUP**

LARKFIELD, NEAR MAIDSTONE, KENT

**SENIOR DRAUGHTSMEN**

The Group Engineering Division invites applications for several posts of Senior Draughtsmen from men possessing at least Ordinary National Certificate and with experience in plant layout and pipework related to heavy engineering. Although experience in paper mill work and/or Higher National Certificate would be an advantage, it is not essential.

Write for application forms to the Personnel Officer, Group Personnel Division, Albert E. Reed and Co., Ltd., Larkfield, Nr. Maidstone, Kent, quoting ref. SD/33. E7863 A

**THE SERVICES OF AN ASSISTANT ENGINEER ARE REQUIRED** in connection with Oil Refinery Maintenance. His immediate duties will relate to Inspection and Preventive Maintenance; applicants should therefore have had experience of this work in chemical works or refineries. The commencing salary will be £1000 to £1250, depending upon experience and qualifications. The successful applicant must be a Corporate Member of a professional Engineering Institution.—Applications should be addressed to the Refinery Manager, Lobitos Oilfields Limited, Ellesmere Port, Cheshire. E1961 A

**TWO ASSISTANT ENGINEERS,** with knowledge of Boiler Design and preferably with experience in the operation of Boiler Plants of various types and prepared to travel, are required to fill vacancies which offer opportunities for future advancement.—BOX No. E7796, "The Engineer." A

**VACANCY FOR FULLY-QUALIFIED ENGINEER,** to take complete charge of varied type contracts in up to £10,000 medium general engineering class. Applicant must have a lively and versatile personality and be prepared to cover detailed design work. Applications must give details of qualifications, experience and salary requirements. Works located in South London, with 150 employees.—BOX No. E1966, "The Engineer." A

**WORKS MANAGER** required for road tanker manufacture and general fabrication. View to becoming General Manager. Large expansion envisaged. Salary according to experience and qualifications. House provided if necessary.—Apply, "Dewco," Bellshill, Scotland. E7879 A

SITUATIONS VACANT

## SENIOR DRAUGHTSMEN, DESIGN ENGINEERS

and

## DESIGN DRAUGHTSMEN

At our Corby Works, one of the largest integrated Iron, Steel and Steel Tube Works in Europe, we have vacancies for MECHANICAL, ELECTRICAL, CIVIL and STRUCTURAL DRAUGHTSMEN.

The vacancies exist in the New Development Drawing-Offices and the Works Drawing-Offices. The work is interesting and offers scope and opportunity to talented young men.

Applicants with Higher National Certificate and experience in either the Iron and Steel industry or heavy engineering are preferred, but men with Ordinary level and relevant experience, or even unqualified men whose experience is outstanding, would be considered.

In addition to these vacancies, there are openings in other Drawing-Offices elsewhere in the Company.

Five-day week. Good welfare, canteen and recreation facilities. Superannuation and life assurance scheme. Staff hostel for single men. Favourable local housing conditions.

GOOD SALARIES BASED ON EXPERIENCE AND QUALIFICATIONS.

Applications will be treated as confidential and should be made, giving details of age, qualifications, experience, and salary required, to :

Manager/Personnel,
STEWARTS AND LLOYDS, LIMITED,
CORBY, Northants.

E123 A

**MSL** have been retained to advise on the appointment of a

## TECHNICAL EXECUTIVE

for a company with a long tradition and skill in the design and manufacture of components in special steels to a wide range of industry. The company, which employs approximately 900 in South Yorkshire, is one of the largest of its type in the world. It has a high reputation for its development work and is continually improving and extending its products.

In the initial stages, the appointment will carry responsibility to the Managing Director for the development of new projects, but it is the intention of the board that this appointment should lead to general control of the company's technical work within a few years. A certain amount of overseas travel may be necessary.

Candidates should have extensive experience in development and design in mechanical engineering and metallurgy (mainly ferrous steels), possess a degree or other professional qualification in mechanical engineering, and have been in a managerial position for 2/3 years. Consideration will be given to those with professional qualifications in metallurgy, provided they have extensive experience in mechanical engineering.

Preferred age 30–35. Starting salary approximately £2,000 according to experience.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1106, to M. B. Berks.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E7883 A

SITUATIONS VACANT

## CONTRACTS ENGINEER

### (Commercial)

REQUIRED FOR

MAYBACH DIESEL DIVISION OF
ARMSTRONG SIDDELEY MOTORS LIMITED

at COVENTRY

This is a new senior, permanent and pensionable appointment and will interest people with a good technical and commercial background particularly in rail traction and marine propulsion, and who are capable of undertaking complete responsibility for the drafting and administration of U.K. and overseas long and short term contracts. Written applications giving age, qualifications, experience and salary required will be treated in strict confidence and should be addressed to :

SALES MANAGER,
Special Projects,
ARMSTRONG SIDDELEY MOTORS LIMITED, COVENTRY

E7852 A

## CADBURY BROTHERS LTD.

HAVE VACANCIES FOR

## DRAUGHTSMEN

for plant design and layout work, with some works experience. The National, or Higher National Certificate, though not essential, would be an advantage. Five-day week, attractive working conditions, Pension Scheme. Provision of accommodation will be considered.

Apply in writing, stating age, qualifications, experience, and salary required, to :

**CHIEF ENGINEER, CADBURY BROS., LTD., BOURNVILLE, BIRMINGHAM**

E131 A

## HEAD OF MACHINE DESIGN & TEST GROUP

### Turbines, Pumps, Compressors

Applications are invited for this appointment, which carries responsibility for the direction and control of a group of engineers and designers engaged in the specification, design and test of rotary and reciprocating pumps, high pressure compressors and turbines.

The designs are complementary to large scale plant installations under home and overseas design and construction contracts. The post is based in London and offers the opportunity of an excellent salary and a most interesting range of work. An engineering degree or membership of the Institution of Mechanical Engineers is essential.

The vacancy arises following the promotion of the present holder of this appointment. Housing assistance can be given.

*Applications, giving full details of age, qualifications, experience and present salary to :*

**The Personnel Manager (Ref. GH/15)**
**BRITISH OXYGEN ENGINEERING LTD.**
**Angel Road, Edmonton, London, N.18.**

E7850 A

SITUATIONS VACANT

## INDUSTRIAL ENGINEERS

A Leading Midland Engineering Group wishes to recruit a few well-qualified Industrial Engineers, ages between 27 and 35, and possessing University Degrees, who have had experience as Industrial Consultants or on Production Planning and Control and Works Study or as a Production Executive.

The immediate appointment would be made to the Central Consulting Staff with the prospect of a senior production management post within a few years. The salary offered would be within the range of £1500 to £2250, depending upon experience and qualifications. There is a group superannuation scheme.

Applications, which will be treated in strict confidence, should be made,—BOX No. E7809, "The Engineer." A

SITUATIONS VACANT

## MAINTENANCE ENGINEER

A Fine Chemicals Company in the South of England requires a Maintenance Engineer. The successful applicant will probably be an A.M.I.Mech.E., with broad general experience in plant maintenance, earning at least £1200 p.a., and capable of exercising management responsibilities. The Company operates an adequate pension plan with insurance cover, and works a five-day week with three weeks' annual holiday.

Write BOX No. E7903, "The Engineer." A

SITUATIONS VACANT

## SALES CONTROLLER

Leading manufacturers of electrical apparatus invite applications for the appointment of Sales Controller, to take charge of the Company's home and overseas sales organisation.

An engineering qualification is necessary and Corporate Membership of the I.E.E. desirable.

Age should not exceed 45. A salary of £2500 per annum with pension provision is offered. The appointment is in the London district.

Send full details of education and experience, particularly in connection with sales, in the strictest confidence, to :—

The Secretary,
Professional Engineers Appointments Bureau,
39, Victoria Street, Westminster, S.W.1.

E7868 A

SITUATIONS VACANT

## TECHNICAL SALES REPRESENTATIVES

Taylor, Taylor & Hobson, Ltd., is enlarging its Sales Force especially for the sale of its Engineers' Measuring Instruments and Machine Tools.

A number of senior appointments are available for area representatives.

The Company seeks active, well-trained men who have received a technical education to H.N.C. standard and have had considerable experience of selling. Command of the French, German or Spanish languages would be an advantage but is not essential.

Training in the Company's products and sales policies is given at the Company's expense but a representative will not be confirmed in his appointment until Management is satisfied with his competence.

A Company car can be provided and there is a Pension Scheme.

Applicants are invited to write in confidence to :—

The General Manager,
Taylor, Taylor & Hobson, Ltd.,
Stoughton Street,
Leicester. E7851 A

## MANAGER

FOR

### PLANT AND TRANSPORT DIVISION

Due to expansion the leading Building and Civil Engineering Contractors in Yorkshire and the North East (employing over 2000 people), invite applications for the post of Manager of their Plant and Transport Division.

Applicants should be qualified engineers (age 32–40) with good commercial and managerial experience. Experience with Contractors' Plant or a Transport fleet preferred. This position, in which managerial ability is as important as technical competence, involves responsibility for :

(*a*) Control of repair and maintenance of an extensive range of contractors' plant and transport.
(*b*) Securing a high rate of utilisation of company owned plant and transport.
(*c*) Control of office, workshop and transport staff.

This interesting new position with responsibility to a director, offers ample scope and prospects to a young manager with the requisite experience, adaptability and initiative.

The position is permanent and offers excellent staff conditions, non-contributory pension scheme, progressive salary, bi-annual bonus and provision of a car. The selected applicant will be required to reside in or near York and assistance with housing will be given if required.

Written applications, which will be dealt with in strict confidence, should state age, full details of experience and qualifications, some indication of commencing salary required and should be addressed for the personal attention of :

P. M. SHEPHERD, *Managing Director*
F. SHEPHERD & SON, LTD.,
BUILDING & CIVIL ENGINEERING CONTRACTORS
BLUE BRIDGE LANE, YORK.

E7845 A

## ASSISTANT ENGINEER

is required by

### SCOTTISH AGRICULTURAL INDUSTRIES LIMITED

to fill a vacancy on the staff of their Ayr Fertiliser Works. The minimum qualifications required are a Higher National Certificate in Mechanical Engineering but preference will be given to candidates with an Engineering Degree or A.M.I.Mech.E. Experience of plant installation and maintenance will be an advantage. The post is permanent and pensionable and the commencing salary will be according to age, qualifications and experience.

Application forms will be forwarded to suitable candidates on receipt of brief details covering age, qualifications and experience, which should be addressed to the Personnel Officer,
Scottish Agricultural Industries Limited,
39, Palmerston Place, Edinburgh, 12,
quoting reference 25/Assistant Engineer.

E7865 A

The world's leading inventors and manufacturers of special purpose precision machinery for the Tobacco Industry have opening in their London Drawing Office for :—

## ELECTRICAL DESIGNER

Desirable applicant should be aged 25–40, with technical qualifications at least up to H.N.C. level, and with a broad background of experience in the design of electrical and electro-mechanical equipment as applied to precision machinery.

This opportunity is permanent and progressive ; it offers immediate pensionable Monthly Staff position with 3 weeks' Annual Holiday and other advantages.

Applications, stating age, qualifications and experience, should be personally addressed in confidence to G. B. Salmon.

MOLINS MACHINE CO. LTD., Evelyn Street, London, S.E.8.

E7704 A

### TEXAS INSTRUMENTS LIMITED

This British Company, one of the foremost manufacturers of Transistors and Rectifiers, seeks the services of a

## PLANT ENGINEER

with experience of plant layout and the planning of electrical and mechanical services for a major factory building, preferably in the electronics industry.

The Company is about to start on a large programme of building which is expected to continue for some years. During this period the man appointed to this post will be directly responsible to the Managing Director for the co-ordination of overall plans. For this purpose he will be required to visit our parent company at Dallas, Texas, and to be responsible for liaison between the two companies and our British and American consulting engineers and architects. It is intended that later he will assume other management responsibilities.

The Company operates a non-contributory Pension Scheme and provides generous life assurance.

Reply to :—The Managing Director,
Texas Instruments, Limited, Dallas Road, Bedford.

E7889

**MSL** have been retained to advise on the appointment of a

## GENERAL MANAGER

for a public company employing 400 in a pleasant market town near London.

The General Manager will control both the manufacturing and selling activities of the company. He will join the board within two years and understudy the Managing Director who retires in about seven years.

The company manufactures a wide range of engineering products including mechanical and electrical fittings for industrial and government use, and special purpose articles to customers' individual requirements.

Candidates must have held responsibility for the production of light engineering equipment, on small batch or one off basis. Experience in applying management control techniques in a small or medium sized company is necessary, and an engineering qualification would be an advantage. Preferred age 35–45. Commencing salary about £2,500 with increased emoluments on appointment to the board.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1112, to W. F. Younger.

MANAGEMENT SELECTION LIMITED
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E7866 A

## SITUATIONS WANTED

**ENGINEER** with wide technical experience requires change. Experienced in management, production and drawing-office, precision electrical/mechanical field. Salary range £1200–£1400. Write.—BOX No. E1979, "The Engineer." B

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Classified Advts. continued on page 124

## FOR HIRE

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**WANTED,** Machines of all Types.
CASH PAID.
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**CHESTERFIELD POWER STATION**

1 M.V. TURBINE SET, dated 1917, 2000kW 6600V, 3000 r.p.m.
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STEAM RANGE PIPEWORK

4 B. & W. BOILERS (One 10k. lb./hr., one 12k. lb./hr, Two 25k lb./hr., installed 1912–1922 with associated Economisers, Superheaters, Conveyors, Elevators, Chain Grate Stokers, Fans and Spares, etc.
1 Peebles 400kW MOTOR CONVERTOR.
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1 Nife 25 cell 35V BATTERY, with Westalite Charging Rectifier.
3 Weir DOUBLE ACTING STEAM PUMPS, 20,000 lbs./hr.
1 Weir DOUBLE ACTING STEAM PUMP, 35,000 lbs./hr.
1 Davenport Pitch Pine 15,000 g.p.h. COOLING TOWER.
1 Davenport Pitch Pine 25,000 g.p.h. COOLING TOWER, both with associated Asbestos Distribution Pipework.

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WANDERER Model 31L 1000 UNIVERSAL LONG THREAD MILLING AND HOBBING MACHINE for internal and external threads, helical and parallel splines, worms, &c. Length of hob spindle travel 39½in. Height of centres 8½in. Hollow spindle 3 ½in. dia.

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E7849 G

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TWO BLISS No. 820 Automatic Strip Feed Power Presses with lid curling and stacker attachment. Completely tooled for blanking, forming and curling 3in. diameter can ends. The machine is mounted on cast iron legs in inclined position. Arranged motor drive for 400/3/50, pressure exerted approximately 20 tons, stroke 3in., maximum length of strip 31in., size of bed 19½in. by 14in., weight approximately 40 cwt.
TAYLOR & CHALLEN No. 370 Open Fronted Upright Power Press, arranged motor drive 415/3/50, complete with guard over drive and operator's automatic safety guard, pressure exerted approximately 20 tons, stroke 3in., Tee slotted bed 27in. by 22½in., weight approximately 34 cwt.
TAYLOR & CHALLEN No. 3 GDP, Geared, Double Sided, Double Action, Cam Action Drawing Press, arranged motor drive 400/440/3/50, punch stroke approximately 7in., blankholder stroke approximately 3½in., between uprights 20½in., tee slotted bed 18in. by 15½in., weight approximately 51 cwt.
BESCO Type EBI, Eccentric Power Punching Press, with adjustable stroke, and adjustable table, arranged motor drive 400/440/3/50, pressure exerted 10 tons, stroke adjustable from ½in. to 1½in., size of table 16½in. by 12in.
TAYLOR & CHALLEN No. 266, Double Sided Geared Power Press, arranged motor drive, 400/440/3/50, fitted with automatic press guard, pressure exerted approximately 40 tons, stroke 1½in., between uprights 18½in., size of plain bed 17½in. by 23in., weight approximately 45 cwt.
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Photographs of the above are available.

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TWW

PRACTICALLY UNUSED 2½ tons CAPACITY TUBULAR SHEAR LEGS, legs 14ft. long, complete with pear-shaped top shackle, in excellent condition. Ready for immediate work.

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40-ton Adamson, standard cab control, 42ft. 3in. span, 400/3/50.
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Surplus Unused Ministry Cranes, mainly still packed. Drawings on request. Inspection invited. Bargain prices about one-third of New.

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RICHARDS 10ft., motor drive through gearing, 2 tool heads on cross rail, table dia. 9ft., admits under cross rail 6ft. 10in., h.p. motor 25.

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AIR COMPRESSORS.—Broomwade 400, 300, 200 and 130 cu. ft.; all motorised ; Reavell Rotary Blowers, 2000 c.f.m., 3–2 p.s.i.
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ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 100 h.p.
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£635 lump sum—" as now standing."—BOX No. E7871," The Engineer." G

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TWW

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E215 G

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Oldfield & Schofield SHAFT STRAIGHTENING PRESS, to take shafts 3in. diam. up to 36in. long.

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One 3-ton Taylor Jumbo Hydraulic Crane, diesel-driven.

One Rapier 1-ton Shop Truck Crane.

5-ton Morris Versatile Diesel/Elec. Mobile Crane on solid rubber tyres.

5-ton Smith Steam Loco Crane, 4ft. 8½in. gauge, 35ft. jib, new 1949.

6-ton Rapier Super Pet./Elec. Mobile Crane on solid rubber tyres.

6-ton Rapier Standard Pet./Elec. Mobile Crane on solid rubber tyres.

Fordson Major Diesel Tractor, complete with Horndraulic shovel equipment.

Fordson Major Diesel Tractor, complete with Horndraulic equipment.

¾ cu. yd. Rapier 410 Diesel-driven Excavator with 4-purpose or dragline equipment.

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E7854 G

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High Frequency Hand Grinding and Polishing Machines. Large stock of mops, bobs, stones, etc., also one Sedgewick segmented blade bending and folding machine, fully motorised, capacity 8ft. 3in. by ¼in., 4ft. 7in. by ⅛in., 3ft. 5in. by ¼in., installed only 18 months.

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| | | *Main Location* | *Auctioneers* |
|---|---|---|---|
| July 7-11 | Passenger and load-carrying vehicles, earth-moving and lifting equipment and their ancillaries, etc. | M.O.S. Storage Depot, Ruddington, Notts. | WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.) |
| July 15-16 | 150 vehicles, machine tools and miscellaneous stores, including :— G.S. trucks, water tankers, Scammell heavy-duty diesel tractors, etc. Cromwell, Denham precision and other lathes, sensitive drilling columns, grinders, power hacksaws, universal milling machine, electric stackers 5 to 20 cwt., generating sets, M.T. spares, tyres and tubes, rubber-tyred bogie wheels, steel tubular racking poles, steel binning, wireless sets and spares, electric cable, engineers' and other hand tools, tarpaulin covers, large quantity of domestic and office furniture, leather gloves, drag ropes, etc. | Central Ordnance Depot, Bicester, Oxon. | MIDLAND MARTS, LTD. (Dept. L), Market Square, Bicester, Oxon. (Tel.: 73.) |
| July 23-24 | Miscellaneous stores, including vehicle tyres, radio equipment, etc. | M.O.S. Storage Depot, Rotherwas, Hereford. | RUSSELL, BALDWIN & BRIGHT, LTD. (Dept. L), 20, King Street, Hereford. (Tel.: 4366.) |
| July 29-30 | Machine tools, textiles, vehicle spares, electrical and miscellaneous stores. | M.O.S. Storage Depot, Byley, Middlewich, Cheshire. (Sale at New Islington Public Hall, Ancoats, Manchester.) | J. H. NORRIS & SON (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.) |

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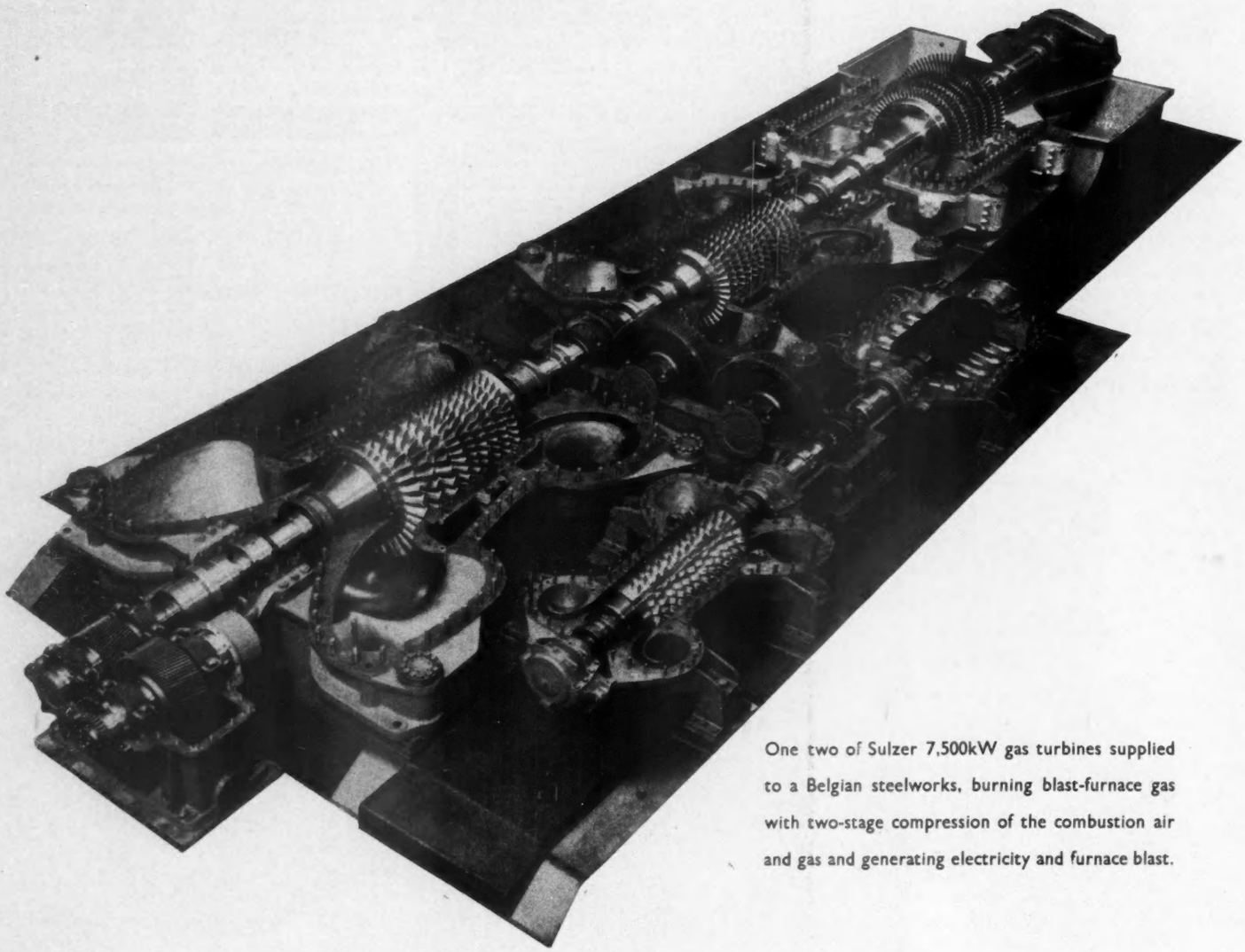

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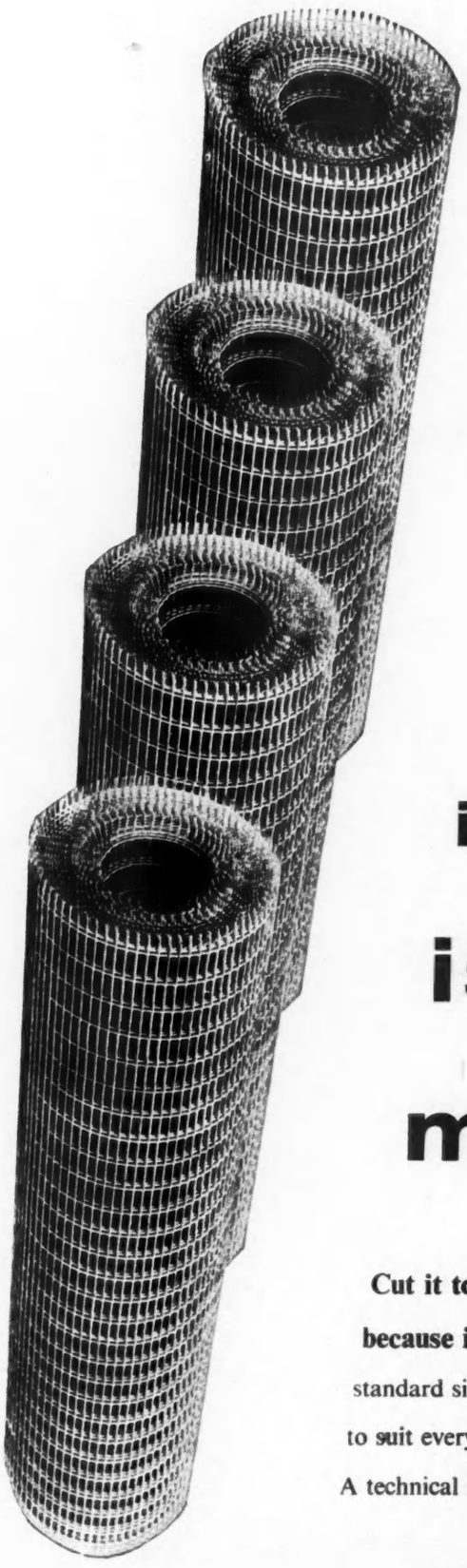

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